

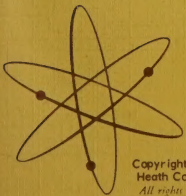
PRICE \$2.00

HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATHKIT® ASSEMBLY MANUAL



SINE-SQUARE AUDIO GENERATOR MODEL IG-18



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595-1179-05

Dear Customer:

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Here's how we aim to keep it that way:

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During your first 90 days of ownership, any parts which we find are defective, either in materials or workmanship, will be replaced or repaired free of charge. And we'll pay shipping charges to get those parts to you — anywhere in the world.

If we determine a defective part has caused your Heathkit electronic product to need other repair, through no fault of yours, we will service it free — at the factory, at any retail Heathkit Electronic Center, or through any of our authorized overseas distributors.

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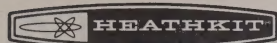
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We hope you'll never need our repair or replacement services, but it's nice to know you're protected anyway — and that cheerful help is nearby.

Sincerely,

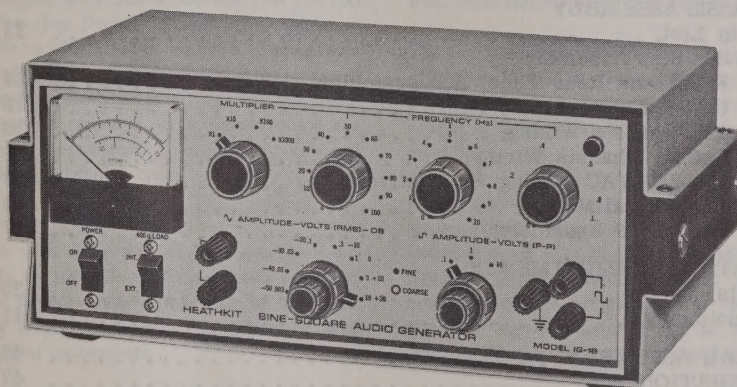
HEATH COMPANY
Benton Harbor, Michigan 49022

Assembly and Operation of the



SINE-SQUARE AUDIO GENERATOR

MODEL IG-18



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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INTRODUCTION

The Heathkit Model IG-18 Sine-Square Audio Generator has been designed for laboratory use as well as for service and testing. Sine wave signals are available between 1 Hz and 100 kHz. Low distortion (less than .1%) sine wave signals are available from 10 Hz to 100 kHz. The output is stepped from .003 volt to 10 volts. These high quality sine wave signals make it ideal for such applications as testing audio amplifiers for gain and frequency response, as a signal source for harmonic distortion measurements, or as an external modulator for an RF signal generator.

Square wave signals with a rise time of 50 nanoseconds are available from 5 Hz to 100 kHz at output levels up to 10 volts. These clean square wave signals can be used for checking frequency response in audio equipment, or as a trigger for testing digital instruments.

The sine and square wave frequencies are identical and the level of each is independently adjustable. Both signals may be used either simultaneously or independently.

The sine wave output will operate into high impedance loads (10 k Ω or higher) in all output ranges, or it will operate into 600 ohm loads in ranges up to 1 volt. The square wave output is designed to operate into loads of 2000 ohms or greater.

Other features include: A panel meter for monitoring the sine wave output; repeatable selection of any frequency; switch-selected 600 ohm internal load; and all solid-state circuitry for maximum reliability. All of these features combine to provide you with a versatile, accurate, and attractive signal source. It will be a valuable and useful addition to your laboratory or workbench.

UNPACKING

This kit is packed in a large shipping carton, which contains smaller packages and a number of loose parts. Some of the smaller packages have numbers 1 through 3 stamped on them (Pack #1, Pack #2, Pack #3). After these three numbered packages have been removed from the large carton, the remaining parts in the carton will make up package #4.

Each assembly section of the Manual contains its own Parts List and Step-By-Step instructions. At the beginning of each Parts List you will be told which numbered package to open. You will also be directed to remove the parts from package #4 that are required to complete that assembly section.

To avoid intermixing parts, do not open any parts packs until you are directed to do so at the beginning of one of the Parts Lists. Any part that is packaged in an individual envelope with a part number on it, should be placed back in its envelope after it is identified until it is called for in a step.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

To order replacement parts, refer to the "Replacement Parts Price List" and use the Parts Order Form furnished with this kit.

WAVE GENERATOR

PARTS LIST

Open package #1 and check each part against the following Parts List. The numbers in parentheses correspond to the numbers on the Wave Generator Parts Pictorial (fold-out from Page 5).

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

RESISTORS

1/2 Watt

(1)1-54	2	15 Ω (brown-green-black)
1-66	2	150 Ω (brown-green-brown)
1-97	3	1100 Ω (brown-brown-red)
1-98	2	1600 Ω (brown-blue-red)
1-89	2	2400 Ω (red-yellow-red)
1-16	2	4700 Ω (yellow-violet-red)
1-20	6	10 k Ω (brown-black-orange)
1-47	1	56 k Ω (green-blue-orange)
1-29	1	220 k Ω (red-red-yellow)

1 Watt

(2)1-56-1	1	1200 Ω (brown-red-red)
-----------	---	-------------------------------

CAPACITORS

(3)20-128	1	470 pF resin
(4)21-16	1	.01 μ F disc
(5)25-200	1	.68 μ F electrolytic

CONTROLS

(6)10-155	2	750 Ω
10-201	2	10 k Ω

DIODES-TRANSISTORS

(7)56-26	2	Crystal diode
(8)56-56	1	Silicon diode
57-65	2	Silicon diode

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

Diodes-Transistors (cont'd.)

(9)417-94	3	2N3416 transistor
417-201	2	X29A829 transistor
(10)417-154	3	2N2369 transistor

HARDWARE

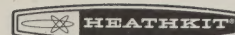
(11)250-89	8	6-32 x 3/8" screw
(12)254-1	7	#6 lockwasher
(13)259-1	1	#6 solder lug
(14)252-3	8	6-32 nut
(15)250-175	1	2-56 x 3/8" screw
(16)254-7	2	#3 lockwasher
(17)252-51	1	2-56 nut

MISCELLANEOUS

(18)260-24	1	Lamp clip
(19)412-66	1	Lamp
85-257-2	1	Wave generator circuit board
		Solder

PARTS FROM PACKAGE #4

(20)200-516	1	Chassis
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
391-34	1	Identification label
490-5	1	Nut starter
	1	Manual (See front cover for part number.)



UNPACKING

This kit is packed in a large shipping carton, which contains smaller packages and a number of loose parts. Some of the smaller packages have numbers 1 through 3 stamped on them (Pack #1, Pack #2, Pack #3). After these three numbered packages have been removed from the large carton, the remaining parts in the carton will make up package #4.

Each assembly section of the Manual contains its own Parts List and Step-By-Step instructions. At the beginning of each Parts List you will be told which numbered package to open. You will also be directed to remove the parts from package #4 that are required to complete that assembly section.

To avoid intermixing parts, do not open any parts packs until you are directed to do so at the beginning of one of the Parts Lists. Any part that is packaged in an individual envelope with a part number on it, should be placed back in its envelope after it is identified until it is called for in a step.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

To order replacement parts, refer to the "Replacement Parts Price List" and use the Parts Order Form furnished with this kit.

HEATHKIT®

CHASSIS PARTS

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

RESISTORS

1-95	.10	560 Ω
1-23	.10	27 k Ω
1-102	.10	82 k Ω

ELECTROLYTIC CAPACITORS

25-193	.60	250 μ F
25-205	1.30	300 μ F
27-110	.20	.047 μ F Mylar

CONTROL-SWITCHES

12-96	1.15	1 M Ω dual control
60-24	.50	Rocker switch

PLASTIC PARTS

70-5	.10	Black test lead insulator
70-6	.10	Red test lead insulator
75-17	.10	Binding post base insulator
75-30	.10	Line cord strain relief, round cord
75-71	.10	Line cord strain relief, flat cord
100-16-2	.10	Binding post cap, black
100-16-18	.10	Binding post cap, red
100-699	.15	Binding post cap, green
207-3	.10	Cable clamp
261-28	.05	Plastic foot
413-10	.10	Red pilot lamp lens
261-30	.10	Line cord retainer

HARDWARE

#6 Hardware

250-227	.05	6-32 x 7/8" phillips head screw
250-26	.05	6-32 x 5/8" screw
250-304	.15	6-32 x 7/16" spacer stud
250-89	.05	6-32 x 3/8" screw
250-229	.05	6-32 x 1/4" phillips head screw
250-303	.15	6-32 x 1/4" decorative head screw
250-365	.05	#6 x 1/4" sheet metal screw
254-1	.05	#6 lockwasher
254-27	.05	#6 external-internal lockwasher
255-15	.05	#6 x 1/2" spacer
259-1	.05	#6 solder lug
252-3	.05	6-32 nut

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

Other Hardware

252-7	.05	Control nut
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-32	.05	Speednut
427-3	.10	Binding post base

METAL PARTS

90-401-2	2.60	Cabinet half shell
100-769	1.55	Front panel
100-770	1.50	Rear panel
100-771	.85	Side rail
204-759-1	.15	End cap
210-35	2.90	Bezel
211-32	.35	Handle

WIRE

Hookup Wire

344-50	.05/ft	Black
344-51	.05/ft	Brown
344-54	.05/ft	Yellow
344-55	.05/ft	Green
344-57	.05/ft	Violet
344-58	.05/ft	Gray

Other Wire

89-23	.75	Line cord
341-1	.10/ft	Black test lead
341-2	.10/ft	Red test lead

KNOBS AND BUSHINGS

455-50	.10	Single knob bushing
455-51	.10	Inner shaft knob bushing
455-52	.10	Outer shaft knob bushing
462-245	.25	Single knob
462-247	.35	Outer shaft knob
462-276	.25	Inner shaft knob

MISCELLANEOUS

253-85	.05	Felt washer
260-16	.10	Alligator clip
407-131	10.60	Meter
412-15	.20	Neon lamp
431-41	.10	2-lug terminal strip
431-35	.10	7-lug terminal strip
432-27	.40	Line cord adapter
438-13	.15	Banana plug
259-20	.05	Solder pin
421-22	.35	3/4 ampere slow-blow fuse

WAVE GENERATOR

PARTS LIST

Open package #1 and check each part against the following Parts List. The numbers in parentheses correspond to the numbers on the Wave Generator Parts Pictorial (fold-out from Page 5).

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

RESISTORS

1/2 Watt

(1) 1-54	2	15 Ω (brown-green-black)
1-66	2	150 Ω (brown-green-brown)
1-97	3	1100 Ω (brown-brown-red)
1-98	2	1600 Ω (brown-blue-red)
1-89	2	2400 Ω (red-yellow-red)
1-16	2	4700 Ω (yellow-violet-red)
1-20	6	10 k Ω (brown-black-orange)
1-47	1	56 k Ω (green-blue-orange)
1-29	1	220 k Ω (red-red-yellow)

1 Watt

(2) 1-56-1	1	1200 Ω (brown-red-red)
------------	---	-------------------------------

CAPACITORS

(3) 20-128	1	470 pF resin
(4) 21-16	1	.01 μ F disc
(5) 25-200	1	.68 μ F electrolytic

CONTROLS

(6) 10-155	2	750 Ω
10-201	2	10 k Ω

DIODES-TRANSISTORS

(7) 56-26	2	Crystal diode
(8) 56-56	1	Silicon diode
57-65	2	Silicon diode

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

Diodes-Transistors (cont'd.)

(9) 417-94	3	2N3416 transistor
417-201	2	X29A829 transistor
(10) 417-154	3	2N2369 transistor

HARDWARE

(11) 250-89	8	6-32 x 3/8" screw
(12) 254-1	7	#6 lockwasher
(13) 259-1	1	#6 solder lug
(14) 252-3	8	6-32 nut
(15) 250-175	1	2-56 x 3/8" screw
(16) 254-7	2	#3 lockwasher
(17) 252-51	1	2-56 nut

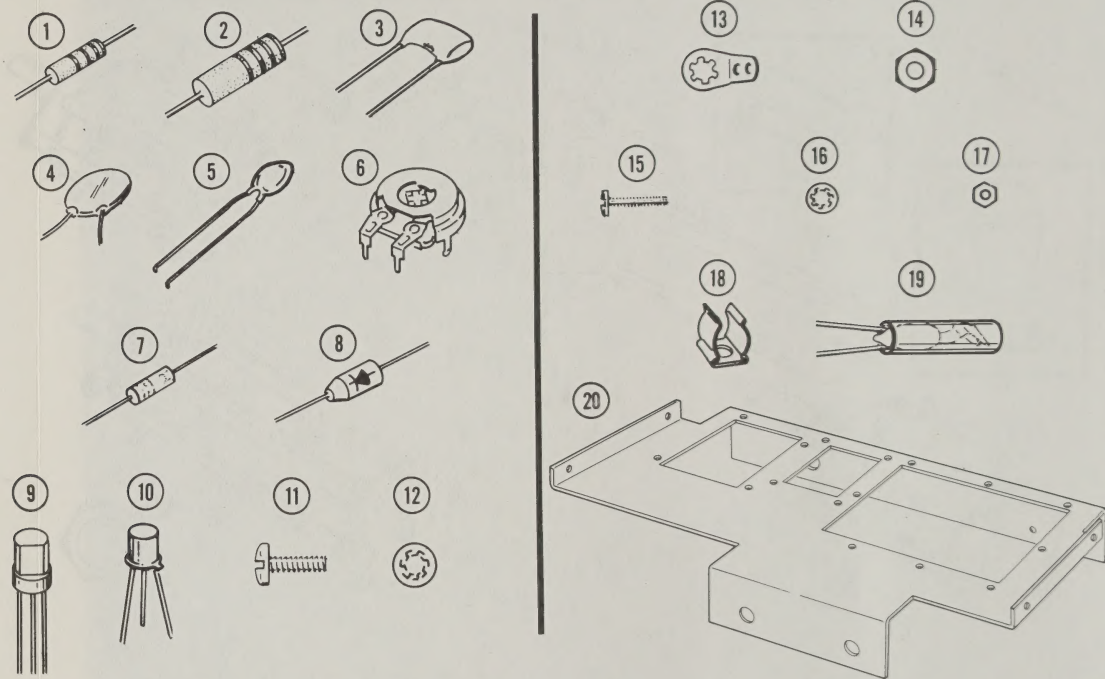
MISCELLANEOUS

(18) 260-24	1	Lamp clip
(19) 412-66	1	Lamp
85-257-2	1	Wave generator circuit board
		Solder

PARTS FROM PACKAGE #4

(20) 200-516	1	Chassis
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
391-34	1	Identification label
490-5	1	Nut starter
	1	Manual (See front cover for part number.)

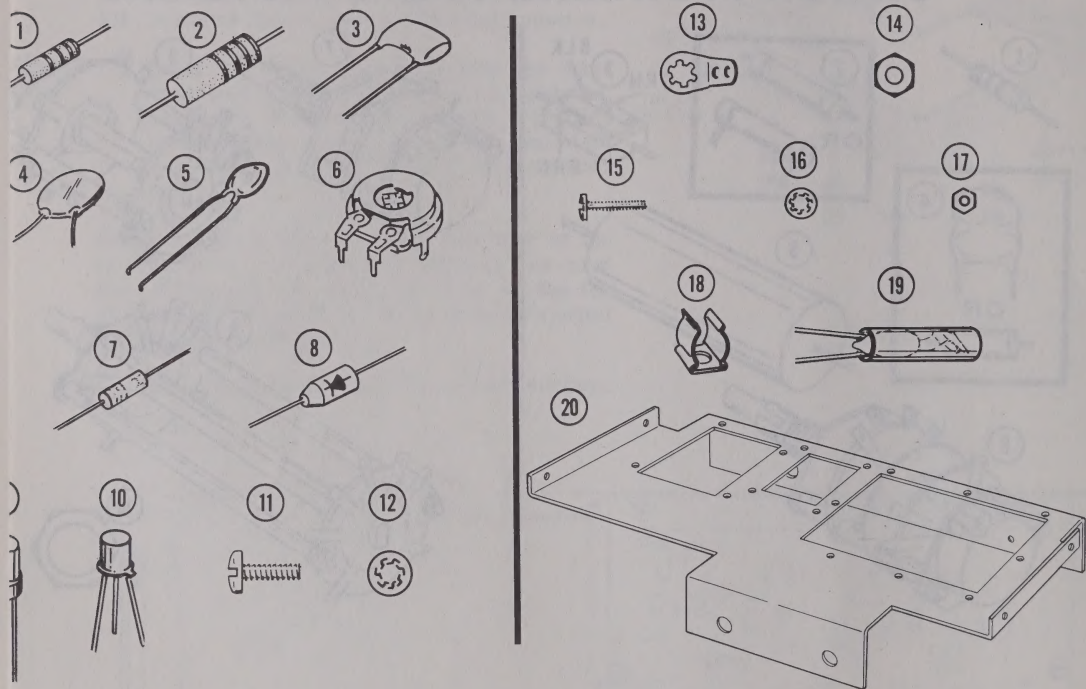
WAVE GENERATOR PARTS PICTORIAL



STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD NO. 100-100

WAVE GENERATOR PARTS PICTORIAL



CIRCUIT BOARD ASSEMBLY

IDENTIFICATION DRAWING



PART NUMBER

The steps on this Page are done in this area of the circuit board.

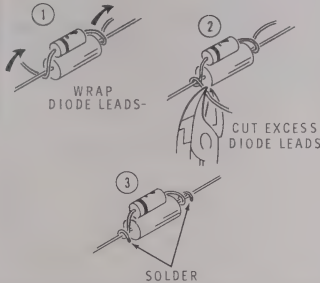
START

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...
WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

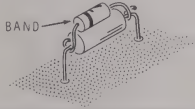


- (✓) 1600 Ω (brown-blue-red).
- (✓) 1200 Ω (brown-red-red) 1 watt.
- (✓) 150 Ω (brown-green-brown).
- (✓) 10 K Ω (brown-black-orange).
- (✓) 10 K Ω (brown-black-orange).

- () Prepare this combination before installing it on the circuit board: 10 K (brown-black-orange) silicon diode (#56-56).



- () Install this combination so that the banded end of the diode matches the markings on the circuit board.



- (✓) Solder all the leads to the foil and cut off the excess lead lengths.

CONTINUE



- (✓) 470 pF resin capacitor.
- (✓) 2400 Ω (red-yellow-red).
- (✓) 1600 Ω (brown-blue-red).
- (✓) 2400 Ω (red-yellow-red).
- (✓) 4700 Ω (yellow-violet-red).
- (✓) Solder all the leads to the foil and cut off the excess lead lengths.

NOTE: Before mounting the lamp clip, bend its sides out to permit the screw head to pass by the ridges in the clip, and to prevent lamp breakage from too much spring tension.

- (✓) Mount the lamp clip with the #2 hardware.

2-56 x 3/8" SCREW

LAMP CLIP

#3 LOCKWASHER

#3 LOCKWASHER

2-56 NUT

- (✓) Slide the lamp into the clip from one end of the clip.

NOTE: Make certain the lamp leads are not crossed or touching each other.

- (✓) Insert the leads through the indicated holes on the circuit board.

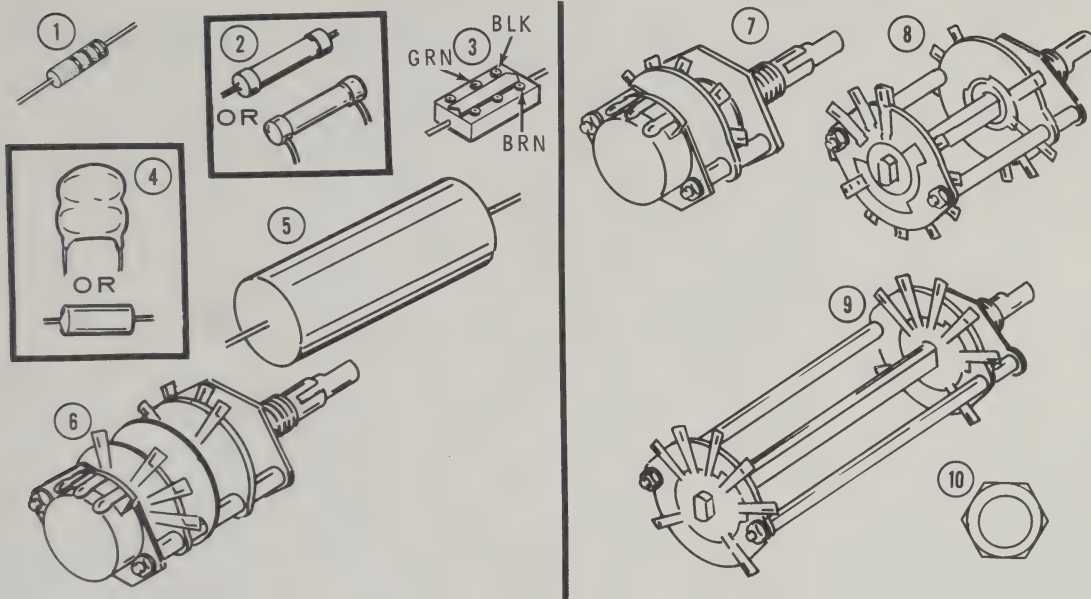
- (✓) Solder both leads to the foil and cut off the excess lead lengths.

PICTORIAL 2

PROCEED TO PICTORIAL 3.

STEP-BY-STEP ASSEMBLY

SWITCH PREWIRING PARTS PICTORIAL



CIRCUIT BOARD MOUNTING

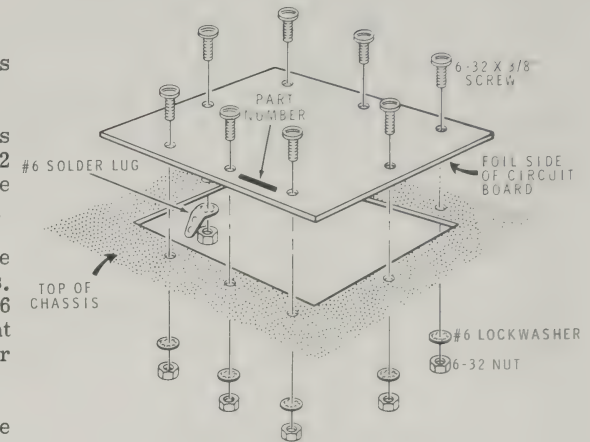
- (✓) Position the chassis in front of you as it is shown in Pictorial 1.

NOTE: A plastic nut starter is supplied with this kit. Use this nut starter to hold and start 6-32 and 2-56 nuts on screws. Refer to Page 3 of the Kit Builders Guide for further information.

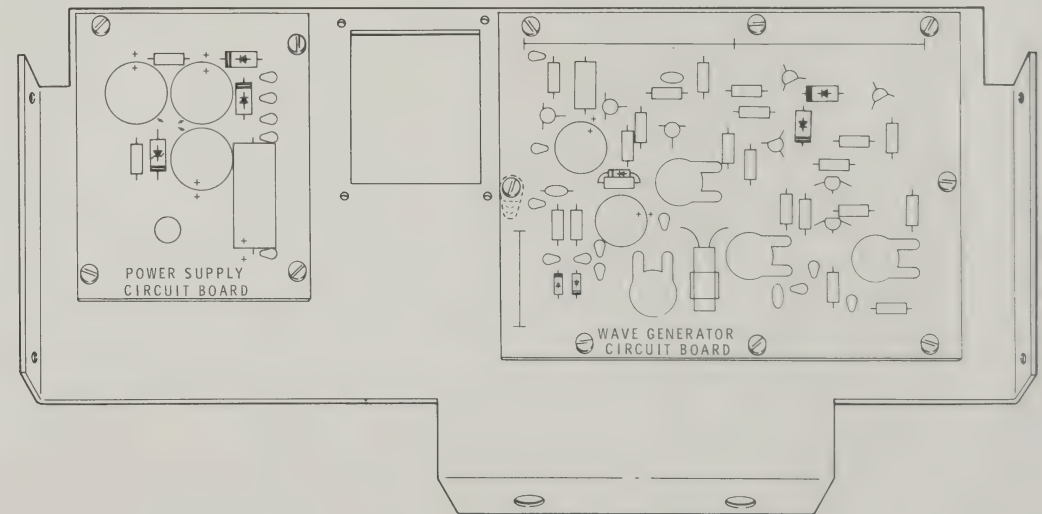
- (✓) Refer to Detail 1A and fasten the wave generator circuit board to the chassis. Use eight 6-32 x 3/8" screws, seven #6 lockwashers, one #6 solder lug, and eight 6-32 nuts. Note the position of the solder lug.

NOTE: Due to its size, only one-half of the circuit board is shown in each of the next four Pictorials. A small drawing at the top of each Pictorial shows the area of the circuit board to be assembled.

Proceed to the Circuit Board Assembly section.



Detail 1A



PICTORIAL 1

CIRCUIT BOARD ASSEMBLY

IDENTIFICATION DRAWING



PART NUMBER

The steps on this Page are done in this area of the circuit board.

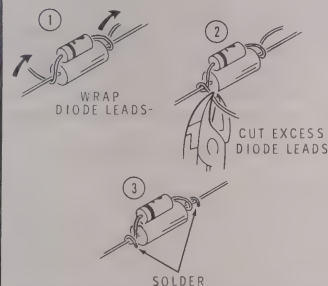
START

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...
WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



- (✓) 1600 Ω (brown-blue-red).
- (✓) 1200 Ω (brown-red-red) 1 watt.
- (✓) 150 Ω (brown-green-brown).
- (✓) 10 K Ω (brown-black-orange).
- (✓) 10 K Ω (brown-black-orange).

- () Prepare this combination before installing it on the circuit board: 10 K (brown-black-orange) silicon diode (#56-56).



- () Install this combination so that the banded end of the diode matches the markings on the circuit board.



- (✓) Solder all the leads to the foil and cut off the excess lead lengths.

CONTINUE



- (✓) 470 pF resin capacitor.
- (✓) 2400 Ω (red-yellow-red).
- (✓) 1600 Ω (brown-blue-red).
- (✓) 2400 Ω (red-yellow-red).
- (✓) 4700 Ω (yellow-violet-red).
- (✓) Solder all the leads to the foil and cut off the excess lead lengths.

NOTE: Before mounting the lamp clip, bend its sides out to permit the screw head to pass by the ridges in the clip, and to prevent lamp breakage from too much spring tension.

- (✓) Mount the lamp clip with the #2 hardware.

2-56 x 3/8" SCREW



LAMP CLIP



#3 LOCKWASHER

#3 LOCKWASHER

2-56 NUT

- (✓) Slide the lamp into the clip from one end of the clip.

NOTE: Make certain the lamp leads are not crossed or touching each other.

- (✓) Insert the leads through the indicated holes on the circuit board.

- (✓) Solder both leads to the foil and cut off the excess lead lengths.

PICTORIAL 2

PROCEED TO PICTORIAL 3.

IDENTIFICATION DRAWING



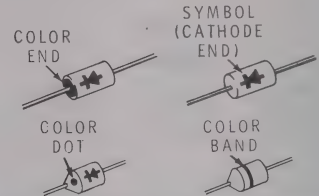
PART NUMBER

The steps on this page are done in this area of the circuit board.

CONTINUE



NOTE: When installing diodes, the cathode end must be positioned as shown on the circuit board. The cathode end is marked with either a color end, color dot, color band or a symbol.



START



(✓) 15 Ω (brown-green-black).

(✓) 15 Ω (brown-green-black).

(✓) 10 k Ω (brown-black-orange).

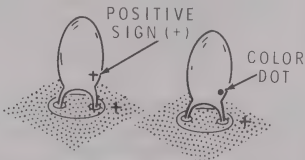
(✓) 10 k Ω (brown-black-orange).

(✓) 4700 Ω (yellow-violet-red).

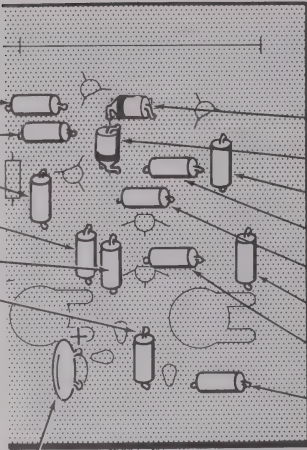
(✓) 56 k Ω (green-blue-orange).

(✓) .68 μ F electrolytic capacitor.
NOTE: Position the positive (+) lead as shown.

MAY BE MARKED WITH POSITIVE SIGN (+) OR COLOR DOT



(✓) Solder all the leads to the foil and cut off the excess lead lengths.



(✓) Silicon diode (#57-65) at D1.

(✓) Silicon diode (#57-65) at D2.

(✓) 150 Ω (brown-green-brown).

(✓) 10 k Ω (brown-black-orange).

(✓) 220 k Ω (red-red-yellow).

(✓) 1100 Ω (brown-brown-red).

(✓) 1100 Ω (brown-brown-red).

(✓) 1100 Ω (brown-brown-red).

(✓) Solder all the leads to the foil and cut off the excess lead lengths.

PROCEED TO PICTORIAL 4.

PICTORIAL 3

START



- (✓) .01 μ F disc capacitor. Turn the chassis over and connect the capacitor lead closest to the edge of the circuit board to the #6 solder lug (S-1). Also, solder each lead to its foil. Cut off excess leads.

SOLDER



NOTE: When installing diodes, be sure to position the cathode end as shown. The cathode end is the banded end.

COLOR BANDS



CATHODE END

- (✓) 1N191 crystal diode (brown-white-brown) at D3. Note the position of the banded end.

- (✓) 1N191 crystal diode (brown-white-brown) at D4. Note the position of the banded end.

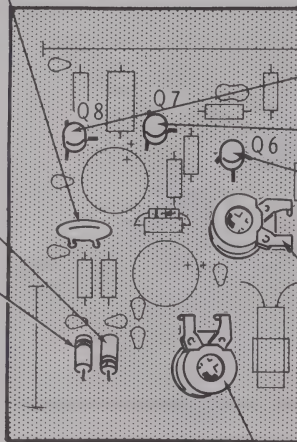
- (✓) Solder all leads to the foil and cut off the excess lead lengths.

IDENTIFICATION DRAWING



PART NUMBER

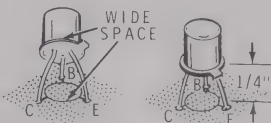
The steps on this page are done in this area of the circuit board.



CONTINUE



NOTE: Refer to the illustration below to determine the location of the collector (C), base (B), and emitter (E) leads of the 2N2369 (#417-154) transistors. Align the leads with the holes in the circuit board, and press down gently until the transistor is about 1/4" from the circuit board. Bend the leads to hold the transistor in place.



- (✓) Transistor 2N2369 (#417-154) at Q8.

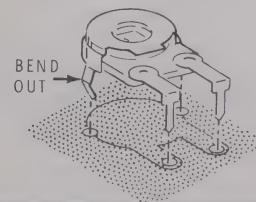
- (✓) Transistor 2N2369 (#417-154) at Q7.

- (✓) Transistor 2N2369 (#417-154) at Q6.

- (✓) Solder all the transistor leads to the foil and remove the excess lead lengths.

NOTE: It may be necessary to bend the control lugs out slightly to hold the control in place until it is soldered.

- () 10 k Ω control (#10-201).



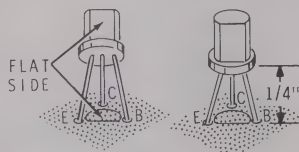
- (✓) 10 k Ω control (#10-201).

- (✓) Solder all the control lugs to the foil.

START



NOTE: When installing transistors in the following steps, be sure to position the E, B, and C leads of each transistor in the corresponding E, B, and C holes of the circuit board. Position the transistor over its outline and 1/4" above the circuit board. Solder all three connections and cut off the excess lead lengths as each transistor is installed.



- (✓) Transistor 2N3416 (#417-94) at Q4.
- (✓) Transistor 2N3416 (#417-94) at Q2.
- (✓) Transistor 2N3416 (#417-94) at Q1.

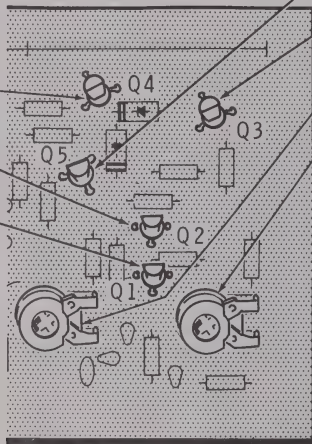
IDENTIFICATION DRAWING



PART NUMBER

The steps on this Page are done in this area of the circuit board.

CONTINUE



- (✓) Transistor X29A829 (#417-201) at Q5.
- (✓) Transistor X29A829 (#417-201) at Q3.
- (✓) 750 Ω control (#10-155).
- (✓) 750 Ω control (#10-155).
- (✓) Solder all the control lugs to the circuit board foil.
- The wave generator circuit board is now complete except for the two 250 μ F, 35 V capacitors. These will be mounted later.
- (✓) Check to make sure all the leads are in the proper location and soldered properly.

FINISH

PROCEED TO PAGE 11

POWER SUPPLY

PARTS LIST

Open package #2 and check each part against the following Parts List. The numbers in parentheses correspond to the numbers on the Power Supply Parts Pictorial.

PART No.	PARTS Per Kit	DESCRIPTION
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RESISTORS-CAPACITORS

(1) 1-1	1	47 Ω 1/2 watt resistor (yellow-violet-black)
1-89	1	2400 Ω 1/2 watt resistor (red-yellow-red)
(2) 25-126	1	50 μ F capacitor

DIODES-TRANSISTOR

(3) 56-66	1	VR 43 zener diode
(4) 57-65	2	Silicon diode
(5) 417-178	1	40389 transistor

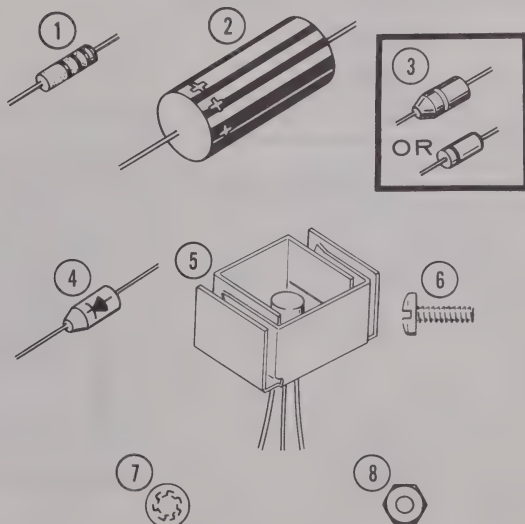
HARDWARE

(6) 250-89	4	6-32 x 3/8" screw
(7) 254-1	8	#6 lockwasher
(8) 252-3	8	6-32 nut

MISCELLANEOUS

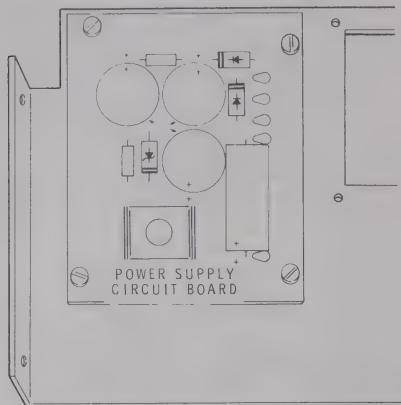
54-205	1	Power transformer
85-256-2	1	Power supply circuit board
344-50	1	Black wire
344-52	1	Red wire

PARTS PICTORIAL

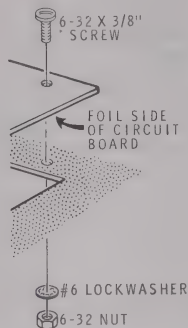


STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD MOUNTING AND ASSEMBLY



Detail 6A



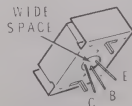
Detail 6B

- (✓) Refer to Detail 6A and fasten the power supply circuit board to the chassis. Use four 6-32 x 3/8" screws, four #6 lockwashers, and four 6-32 nuts as shown in Detail 6B.

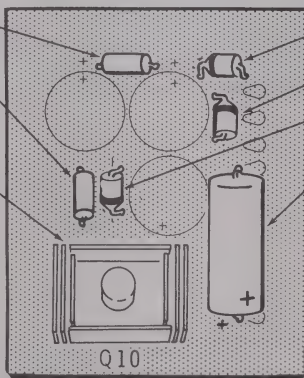
Perform the steps on Pictorial 6.

START

- (✓) 47 Ω (yellow-violet-black).
- (✓) 2400 Ω (red-yellow-red).
- (➔) Install a 40389 transistor (#417-178) at Q10. The collector (C) and emitter (E) leads are on either side of the wide space. Line up each lead with the correct hole and position the transistor on the circuit board.



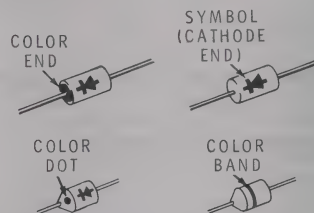
- (✓) Solder all the leads to the foil and cut off the excess lead lengths.



PICTORIAL 6

CONTINUE

NOTE: When installing diodes, the cathode end must be positioned as shown on the circuit board. The cathode end is marked with either a color end, color dot, color band, or a symbol.



- (✓) Silicon diode (#57-65) at D5.
- (✓) Silicon diode (#57-65) at D6.
- (✓) Zener diode VR 43 (#56-66) at D7.
- (✓) .50 μ F tubular capacitor. NOTE: Match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board.
- (✓) Solder all the leads to the foil and cut off the excess lead lengths.

This completes the construction of the power supply circuit board except for the three 300 μ F 60 V capacitors which will be mounted later.

FINISH

Proceed with the mounting of the power transformer.

Refer to Pictorial 7 (fold-out from Page 17) and to Detail 7A for the following steps.

- (✓) Mount the power transformer to the underside of the chassis with four #6 lockwashers, and four 6-32 nuts.

Connect the power transformer leads to the power supply circuit board as follows:

- (✓) One red to U (S-1).
- (✓) Red-yellow to V (S-1).
- (✓) The other red to X (S-1).

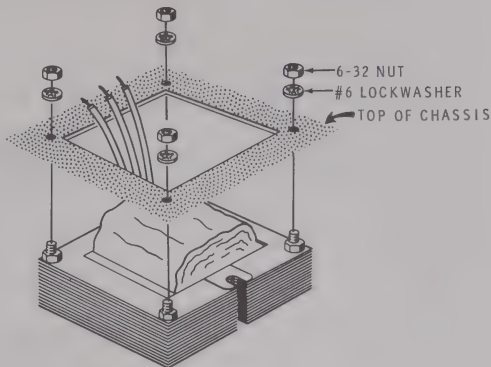
NOTE: When wiring this kit, you may find it easier to prepare the lengths of hookup wire ahead of time, as in the following step. The wires are listed in the order in which they will be used. Remove 1/4" of insulation from the ends of each wire.

- (✓) Prepare the following lengths of hookup wire:

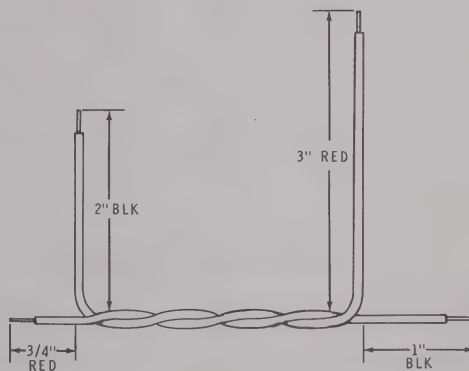
6" red
5-1/2" black

- (✓) Twist these two wires together to form a twisted pair as shown in Detail 7B.
- (✓) At the end of this twisted pair with the 2" black wire, connect the black wire to hole Y NEG (S-1) and the red wire to hole Z POS (S-1) in the power supply circuit board.
- (✓) At the other end of this twisted pair, connect the 1" black wire to hole C NEG (S-1) and the 3" red wire to hole A POS (S-1) in the wave generator circuit board.

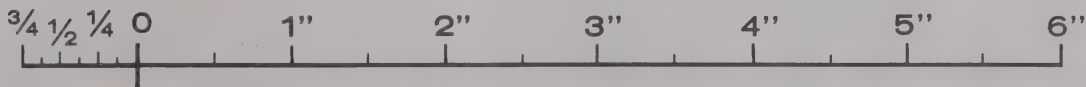
The chassis subassembly is now complete. Recheck your work; then proceed to the switch prewiring.



Detail 7A



Detail 7B



SWITCH PREWIRING

PARTS LIST

Open package #3 and check each part against the following Parts List. The numbers in parentheses correspond to the numbers on the Parts Pictorial (fold-out from Page 6).

PART No.	PARTS Per Kit	DESCRIPTION	PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS			Capacitors (cont'd.)		
(1)1-83	1	56 Ω (green-blue-black)	27-83	1	.05 μF
1-84	1	62 Ω (blue-red-black)	(5)27-82	1	.5 μF
1-66	1	150 Ω (brown-green-brown)	27-81	1	5 μF
1-94	1	390 Ω (orange-white-brown)			
1-63	2	510 Ω (green-brown-brown)	SWITCHES-CONTROL NUT		
1-131	1	620 Ω (blue-red-brown)	(6)63-485	1	8-position rotary with 5000 Ω control
1-96	1	750 Ω (violet-green-brown)	(7)63-486	1	3-position rotary with 400 Ω control
1-97	5	1100 Ω (brown-brown-red)	(8)63-487	2	11-position rotary
1-98	5	1600 Ω (brown-blue-red)	(9)63-488	1	4-position rotary
1-89	1	2400 Ω (red-yellow-red)	(10)252-7	1	Control nut
1/2 Watt, 1%			WIRE		
(2)2-249	2	2500 Ω (2.5 k Ω)	344-50	1	Black wire
2-248	2	3300 Ω (3.3 k Ω)	344-51	1	Brown wire
2-247	2	5000 Ω (5 k Ω)	344-53	1	Orange wire
2-50	2	10 k Ω	344-54	1	Yellow wire
2-97	2	25 k Ω	344-55	1	Green wire
2-98	2	33.3 k Ω	344-56	1	Blue wire
2-99	2	50 k Ω	344-59	1	White wire
2-11	2	100 k Ω			
CAPACITORS					
(3)20-55	1	500 pF			
(4)27-84	1	.005 μF			

STEP-BY-STEP ASSEMBLY

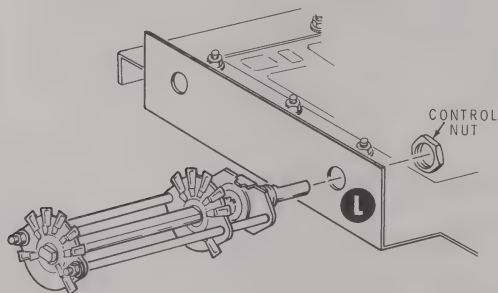
All of the rotary switch wafers have twelve lug locations, numbered 1 through 12. In some switches not all twelve locations are used, but each location will still be numbered. Lug numbering runs clockwise as viewed from the knob end of the switch. The switch wafers are designated "F" for front and "R" for rear, F2, for example, is lug number 2 on the front wafer.

For your wiring convenience, each switch will be temporarily mounted to the chassis while it is prewired.

MULTIPLIER SWITCH

Refer to Pictorial 8 for the following steps.

- () Refer to Detail 8A and mount the 4-position rotary switch (#63-488) in chassis hole L. Use a control nut. Turn the nut down only finger tight.



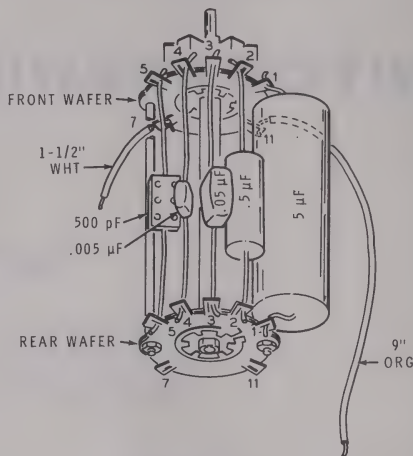
Detail 8A

Connect the components and wires to the Multiplier switch as directed in the following steps.

NOTE: Either end of the following five capacitors may be connected to either the front or rear wafer.

- (✓) Connect a $.5 \mu\text{F}$ capacitor from lug F2 (S-1) to lug R2 (S-1).
- (✓) Connect a $5 \mu\text{F}$ capacitor from lug F1 (S-1) to lug R1 (S-1).

MULTIPLIER SWITCH (63-488)



PICTORIAL 8

- (✓) Connect a $.05 \mu\text{F}$ capacitor from lug F3 (S-1) to lug R3 (S-1).
- (✓) Connect a $.005 \mu\text{F}$ capacitor from lug F4 (S-1) to lug R4 (S-1).
- (✓) Connect a 500 pF capacitor from lug F5 (S-1) to lug R5 (S-1).
- (✓) Prepare the following lengths of hookup wire:
 - 1-1/2" white
 - 9" orange
- (✓) Connect one end of the 1-1/2" white wire to lug F7 (S-1); the other end will be connected later.
- (✓) Connect one end of the 9" orange wire to lug F11 (S-1); the other end will be connected later.

This completes the prewiring of the Multiplier switch. Remove the switch from the chassis and inspect your work. All of the lugs on both wafers should be soldered except lugs R7 and R11 which will be used later. Set the switch aside until it is called for later.

TENS FREQUENCY SWITCH

Refer to the top view of Pictorial 9 (fold-out from this page) for the following steps.

- (✓) Fasten an 11-position rotary switch (#63-487) in chassis hole L. Use a control nut turned down finger tight. Refer to the lugs on the rear wafer for proper positioning of the switch.

NOTE: Use 1% resistors in the following steps. Center each resistor between the wafers before soldering.

- (✓) Pass one lead of a 3300 Ω (3.3 k Ω) resistor through lug R5 (NS). Bend the lead so it lies beside lugs R6 (NS) and R7 (NS); then connect the end to lug R8 (NS). Do not allow the lead to touch the switch spacer post or the nut.
- (✓) Connect the other lead of this resistor to lug F5 (S-1).

NOTE: Where a wire passes through a connection and then goes to another point (or passes beside the connection and comes in contact with it), it will count as two wires in the solder instructions (S-2), one entering and one leaving the connection.

- (✓) Connect one lead of a 2500 Ω (2.5 k Ω) resistor to lug F6 (S-1). Insert the other lead through lug R6 and around the wire passing by R6 (S-3).
- (✓) Connect a 10 k Ω resistor from lug F7 (S-1) to lug R7 (S-3).
- (✓) Connect a 5000 Ω (5 k Ω) resistor from lug F8 (S-1) to lug R8 (NS). Be sure to solder both lugs at F8.

Refer to the bottom view of Pictorial 9 for the following steps.

- (✓) Pass one lead of a 3300 Ω (3.3 k Ω) resistor through lug F11 (NS). Bend the lead so it lies beside lugs F12 (NS) and F1 (NS); then connect the end to lug F2 (NS). Now solder lug F11 (S-2).

- (✓) Connect the other lead of this resistor to lug R11 (S-1).

- (✓) Connect a 2500 Ω (2.5 k Ω) resistor from lug F12 (S-3) to lug R12 (S-1).

- (✓) Connect a 10 k Ω resistor from lug F1 (S-3) to lug R1 (S-1).

- (✓) Connect a 5000 Ω (5 k Ω) resistor from lug F2 (NS) to lug R2 (S-1). Solder both lugs at R2.

- () Prepare the following lengths of hookup wire:

2" brown
5" brown
3-1/2" yellow
3" yellow
2-1/2" yellow

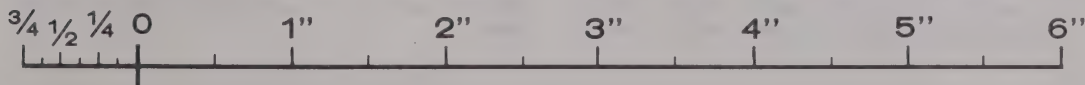
- (✓) Connect the 2" brown wire between lugs F2 (S-3) and R5 (NS).

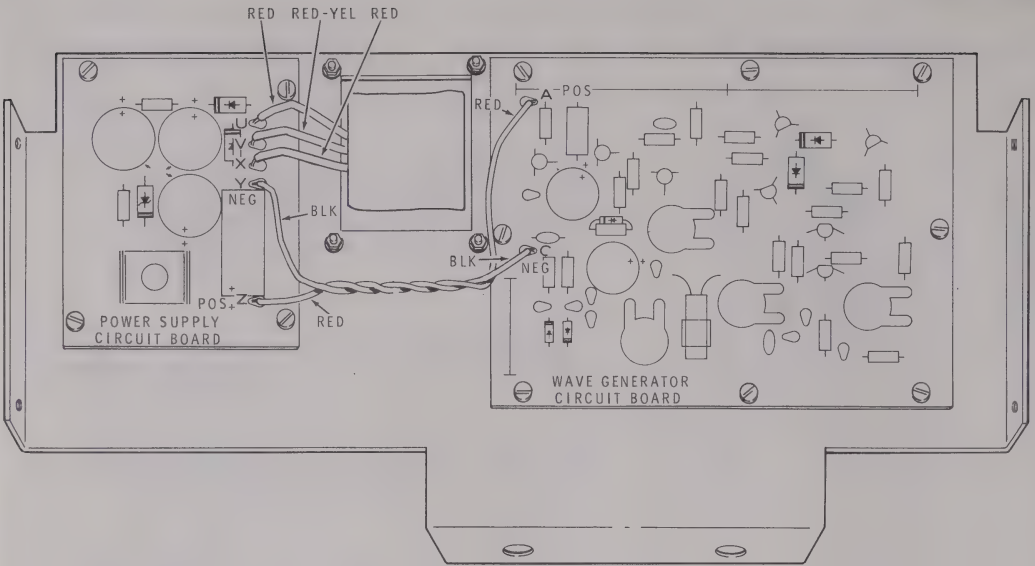
- (✓) Connect one end of the 5" brown wire to lug R5 (S-4). The other end of this wire will be connected later.

NOTE: In the next step, position the three yellow wires as shown in Pictorial 9.

- (✓) Connect one end of the 3-1/2", the 2-1/2", and the 3" yellow wires to lug R10 (S-3). Solder both lugs at R10. The free ends of these wires will be connected later.

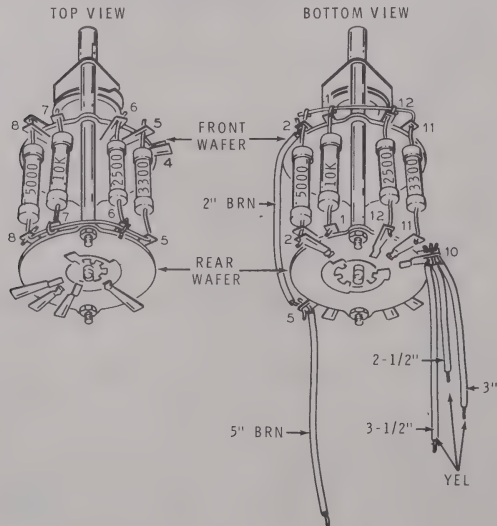
This completes the prewiring of the Tens Frequency switch. All lugs should be soldered except the lugs at F4 which have nothing connected to them and lug R8 which has a 5000 Ω resistor and a wire attached to it. These lugs will be wired to and soldered later. Remove the switch from the chassis and set it aside until it is called for later.





PICTORIAL 7

**TENS FREQUENCY SWITCH
(63-487)**



PICTORIAL 9

SQUARE WAVE AMPLITUDE SWITCH

Refer to Pictorial 11 for the following steps.

- (✓) Fasten the 3-position rotary switch (#63-486) in chassis hole L. Use a control nut turned down finger tight.

NOTE: When you install resistors on the Square Wave Amplitude switch, position each resistor as shown in the Pictorial.

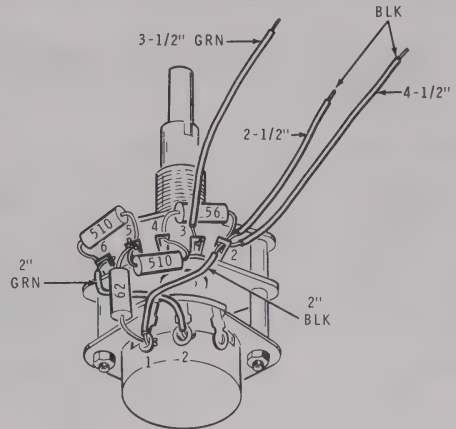
- (✓) Connect a 510 Ω (green-brown-brown) resistor from lug 6 (NS) to lug 5 (NS).
- (✓) Connect a 510 Ω (green-brown-brown) resistor from lug 5 (NS) to lug 4 (NS).
- (✓) Connect a 62 Ω (blue-red-black) resistor from lug 5 (S-3) to control lug 1 (NS).
- (✓) Connect a 56 Ω (green-blue-black) resistor from lug 4 (S-2) to lug 2 (NS).
- (✓) Prepare the following lengths of hookup wire:

2" green
2" black
3-1/2" green
2-1/2" black
4-1/2" black

- (✓) Connect a 2" green wire from lug 6 (S-2) to control lug 2 (S-1).
- (✓) Connect a 2" black wire from lug 2 (NS) to control lug 1 (S-2).

NOTE: Only one end of a wire will be connected to the switch in each of the next three steps. The free ends will be connected later.

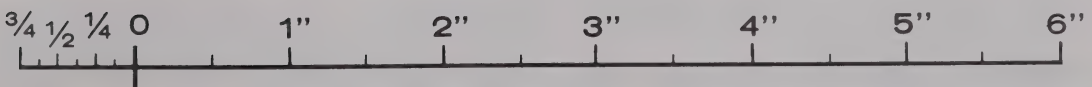
SQUARE WAVE AMPLITUDE SWITCH (63-486)



PICTORIAL 11

- (✓) Connect a 3-1/2" green wire to lug 3 (S-1).
- (✓) Connect a 2-1/2" black wire to lug 2 (NS).
- (✓) Connect a 4-1/2" black wire to lug 2 (S-4).

This completes the prewiring of the Square Wave Amplitude switch. All switch lugs and control lugs 1 and 2 should have soldered connections. Control lug 3 should have no connections. Remove the switch from the chassis and set it aside until it is called for later.



SINE WAVE AMPLITUDE SWITCH

Refer to Pictorial 12 view A for the following steps.

- () Fasten the 8-position rotary switch (#63-485) in chassis hole L. Use a control nut turned down finger tight.

NOTE: The Sine Wave Amplitude switch will have many resistors on it that pass through and quite close to the switch itself. Therefore, be sure to position each resistor as it is shown in the Pictorial. Do not allow the resistor body or leads to touch other parts. In particular, make sure that the resistors do not touch the moving parts or posts of the switch.

- (✓) Connect an 1100 Ω (brown-brown-red) resistor from lug F8 (NS) to lug F5 (NS).
- (✓) Connect a 750 Ω (violet-green-brown) resistor from lug F5 (NS) to lug F7 (NS).
- (✓) Connect a 1600 Ω (brown-blue-red) resistor from lug F7 (S-2) to lug F8 (NS).
- (✓) Connect a 1600 Ω (brown-blue-red) resistor from lug F8 (S-3) to lug F9 (NS).
- (✓) Connect a 1600 Ω (brown-blue-red) resistor from lug F9 (NS) to lug R10 (NS).
- (✓) Pass one lead of an 1100 Ω (brown-brown-red) resistor through lug R5 (NS) to control lug 1 (S-1). Use the full length of the lead.
- (✓) Connect the other lead of this resistor to lug R10 (NS).

Refer to Pictorial 12 View B for the following steps.

- (✓) Connect an 1100 Ω (brown-brown-red) resistor from lug F9 (S-3) to lug F3 (NS).
- (✓) Prepare two 1100 Ω (brown-brown-red) resistors by attaching and soldering the leads at one end as shown in Detail 12A.
- (✓) Connect the common lead of this pair of resistors to lug R3 (NS).
- (✓) At the other end of this pair, connect one resistor to lug R12 (NS) and the other resistor to lug R11 (NS).
- (✓) Connect a 1600 Ω (brown-blue-red) resistor from lug R10 (S-3) to lug R11 (NS).

- (✓) Connect a 1600 Ω (brown-blue-red) resistor from lug R11 (S-3) to lug R12 (NS).

- (✓) Connect a 390 Ω (orange-white-brown) resistor from lug R12 (S-3) to lug R1 (NS).

- (✓) Connect a 2400 Ω (red-yellow-red) resistor from lug R1 (S-2) to lug R2 (NS).

- (✓) Connect a 150 Ω (brown-green-brown) resistor from lug R2 (NS) to control lug 2 (S-1).

- (✓) Connect one lead of a 620 Ω (blue-red-brown) resistor to lug R2 (S-3). Use the full length of the lead. Cut off the other lead at a point 3/4" from the resistor body. This lead will be connected later.

- (✓) Prepare the following lengths of hookup wire:

1-1/2" blue
5" blue
3" blue
2-1/2" blue
1-1/4" black

- (✓) Connect a 1-1/2" blue wire between lugs F10 (S-1) and R9 (S-1).

NOTE: Each of the next five wires will have only one end connected to the switch. The free ends will be connected later.

- (✓) Connect a 5" blue wire to lug F4 (S-1).

- (✓) Connect a 3" blue wire to lug F6 (S-1).

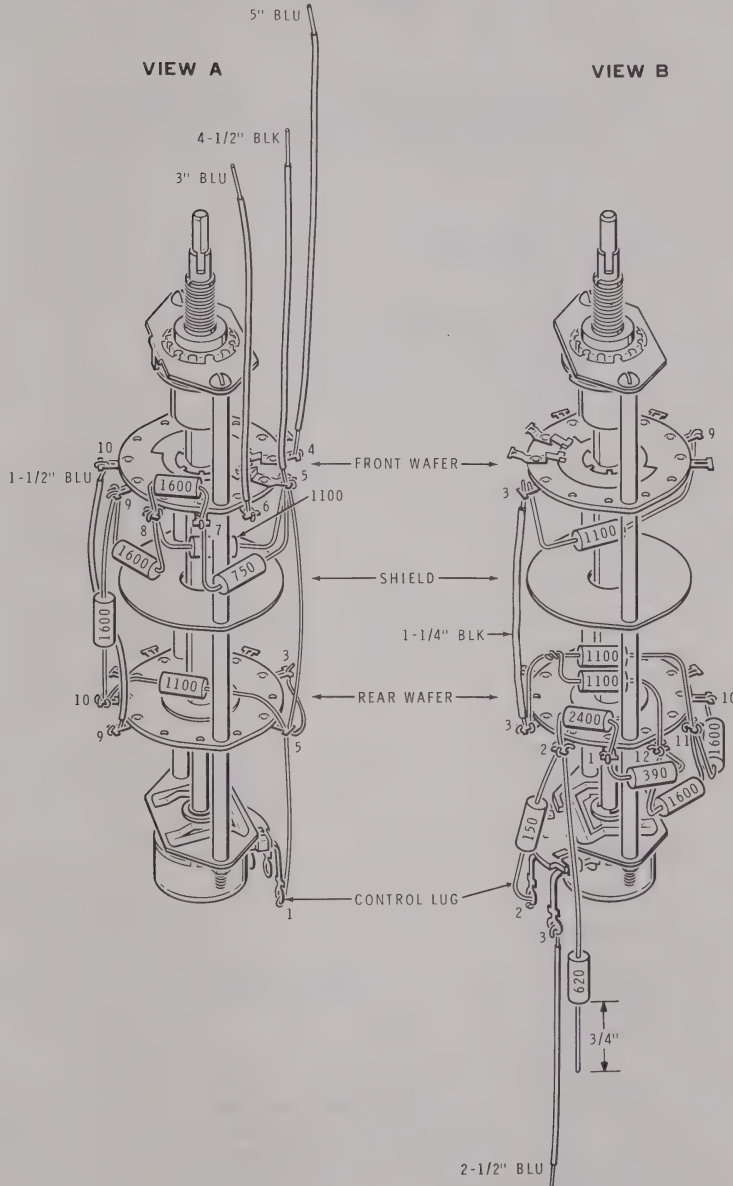
- (✓) Connect a 2-1/2" blue wire to control lug 3 (S-1).

- (✓) Connect a 1-1/4" black wire from lug F3 (S-2) to lug R3 (NS).

- (✓) Prepare a 4-1/2" black hookup wire by removing 1/4" of insulation from one end and 2" of insulation from the other end. Pass the 2" stripped end through lugs F5 (S-4) and R5 (S-4) to lug R3 (S-3). Make sure that the wire does not touch the shield plate.

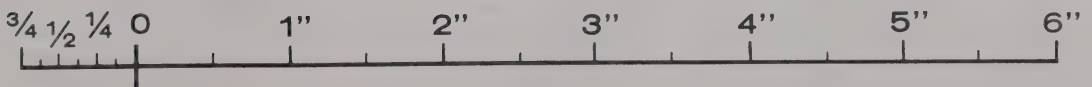
This completes prewiring the Sine Wave Amplitude switch. All lugs on both switch wafers and on the control should be soldered. Remove the switch from the chassis and set it aside until it is called for later.

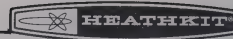
SINE WAVE AMPLITUDE SWITCH
(63-485)



Detail 12A

PICTORIAL 12





CHASSIS ASSEMBLY

PARTS LIST

Check package #4, which consists of all the remaining parts, against the following Parts List. The numbers in parentheses correspond to the numbers on the Chassis Assembly Parts Pictorial (fold-out from Page 25).

PART No.	PARTS Per Kit	DESCRIPTION	PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS			Plastic Parts (cont'd.)		
(1) 1-95	1	560 Ω (green-blue-brown)	(8)75-71	1	Line cord strain relief, flat cord
1-23	1	27 k Ω (red-violet-orange)	(9)100-16-2	2	Binding post cap, black
1-102	2	82 k Ω (gray-red-orange)	100-16-18	2	Binding post cap, red
CAPACITORS			100-699	1	Binding post cap, green
Electrolytic			(10)207-3	1	Cable clamp
(2) 25-193	2	250 μ F	(11)261-28	4	Plastic foot
25-205	3	300 μ F	(12)413-10	1	Red pilot lamp lens
Mylar*			(13)261-30	2	Line cord retainer
(3)27-110	1	.047 μ F	HARDWARE		
CONTROL-SWITCHES			#6 Hardware		
(4)12-96	1	1 M Ω dual control	(14)250-227	4	6-32 x 7/8" phillips head screw
(5)60-24	2	Rocker switch	(15)250-26	4	6-32 x 5/8" screw
PLASTIC PARTS			(16)250-304	4	6-32 x 7/16" spacer stud
70-5	1	Black test lead insulator	(17)250-89	10	6-32 x 3/8" screw
70-6	1	Red test lead insulator	(18)250-229	8	6-32 x 1/4" phillips head screw
(6)75-17	9	Binding post base insulator	(19)250-303	4	6-32 x 1/4" decorative head screw
(7)75-30	1	Line cord strain relief, round cord**	(20)250-365	4	#6 x 1/4" sheet metal screw
*DuPont Registered Trademark			(21)254-1	11	#6 lockwasher
**This strain relief is supplied to be used in areas mainly outside the U. S., where 2- or 3-lead round cords are required.			(22)254-27	1	#6 external-internal lock-washer
			(23)255-15	4	#6 x 1/2" spacer
			(24)259-1	6	#6 solder lug
			(25)252-3	15	6-32 nut

PART No.	PARTS Per Kit	DESCRIPTION
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Other Hardware

(26)252-7	5	Control nut
(27)253-10	6	Control flat washer
(28)254-4	6	Control lockwasher
(29)252-32	1	Speednut
(30)427-3	5	Binding post base

METAL PARTS-HANDLE

(31)90-401-2	2	Cabinet half shell
100-769	1	Front panel
100-770	1	Rear panel
(32)100-771	2	Side rail
(33)204-759-1	4	End cap
(34)210-35	1	Bezel
(35)211-32	2	Handle

WIRE**Hookup Wire**

344-50	1	Black
344-51	1	Brown
344-54	1	Yellow
344-55	1	Green
344-57	1	Violet
344-58	1	Gray

PART No.	PARTS Per Kit	DESCRIPTION
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Other Wire

89-23	1	Line cord
341-1	1	Black test lead
341-2	1	Red test lead

KNOBS AND BUSHINGS

(36)455-50	4	Single knob bushing
(37)455-51	2	Inner shaft knob bushing
(38)455-52	2	Outer shaft knob bushing
(39)462-245	4	Single knob
(40)462-247	2	Outer shaft knob
(41)462-276	2	Inner shaft knob

MISCELLANEOUS

(42)253-85	2	Felt washer
(43)260-16	2	Alligator clip
407-131	1	Meter
(44)412-15	1	Neon lamp
(45)431-41	1	2-lug terminal strip
(46)431-35	1	7-lug terminal strip
(47)432-27	1	Line cord adapter
(48)438-13	2	Banana plug
(49)259-20	4	Solder pin
(50)421-22	1	Fuse, 3/4 ampere slow blow

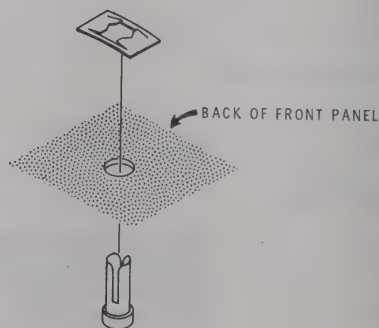
STEP-BY-STEP ASSEMBLY

FRONT AND REAR PANEL SUBASSEMBLIES

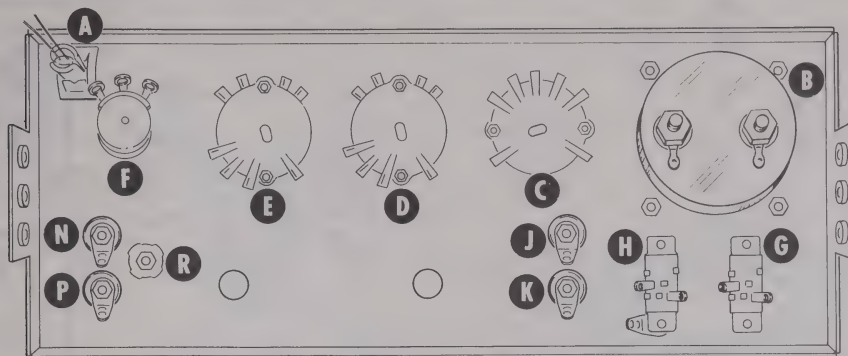
Refer to Pictorial 13 for the following steps.

- (✓) Place a soft cloth on your work surface to protect the front panel from being scratched in the following steps. Then position the front panel as shown.
- (✓) Mount the pilot lamp lens at A as shown in Detail 13A. The lens should be tight against the front of the panel and the speednut pressed down tightly.

NOTE: When you install the binding post bases in the following steps, be sure the hole through each binding post base is in a horizontal position.

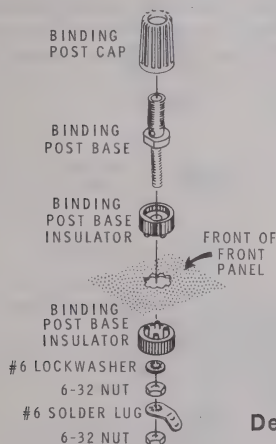


Detail 13A



PICTORIAL 13

- (✓) Refer to Detail 13B and install a binding post base at J. Use two binding post base insulators, a #6 lockwasher, a #6 solder lug, and two 6-32 nuts. Be sure the binding post insulators are seated within the mounting hole. Position the solder lug as shown in Pictorial 13.



Detail 13B

- (✓) In a like manner, install binding posts at locations K, N, and P.

- (✓) Refer to Detail 13C and install the ground binding post at location R. Use a binding post base, one insulator, an external-internal lockwasher and a 6-32 nut.

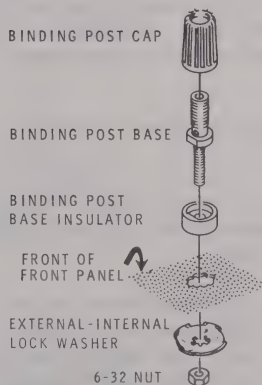
- (✓) Install red binding post caps at locations J and N.

- (✓) Install black binding post caps at locations K and P.

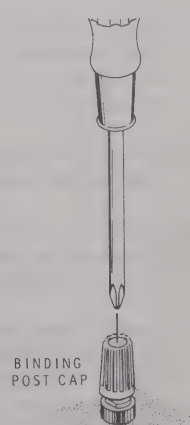
- (✓) Install the green binding post cap at location R.

NOTE: The following step is optional, and is intended to prevent the removal and loss of the binding post caps.

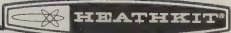
- (✓) Refer to Detail 13D and tap the handle of a phillips screwdriver with a hammer to enlarge the open end of each binding post.



Detail 13C



Detail 13D



PART No.	PARTS Per Kit	DESCRIPTION
Other Hardware		
(26)252-7	5	Control nut
(27)253-10	6	Control flat washer
(28)254-4	6	Control lockwasher
(29)252-32	1	Speednut
(30)427-3	5	Binding post base

METAL PARTS-HANDLE

(31)90-401-2	2	Cabinet half shell
100-769	1	Front panel
100-770	1	Rear panel
(32)100-771	2	Side rail
(33)204-759-1	4	End cap
(34)210-35	1	Bezel
(35)211-32	2	Handle

WIRE

Hookup Wire

344-50	1	Black
344-51	1	Brown
344-54	1	Yellow
344-55	1	Green
344-57	1	Violet
344-58	1	Gray

PART No.	PARTS Per Kit	DESCRIPTION
Other Wire		
89-23	1	Line cord
341-1	1	Black test lead
341-2	1	Red test lead

KNOBS AND BUSHINGS

(36)455-50	4	Single knob bushing
(37)455-51	2	Inner shaft knob bushing
(38)455-52	2	Outer shaft knob bushing
(39)462-245	4	Single knob
(40)462-247	2	Outer shaft knob
(41)462-276	2	Inner shaft knob

MISCELLANEOUS

(42)253-85	2	Felt washer
(43)260-16	2	Alligator clip
407-131	1	Meter
(44)412-15	1	Neon lamp
(45)431-41	1	2-lug terminal strip
(46)431-35	1	7-lug terminal strip
(47)432-27	1	Line cord adapter
(48)438-13	2	Banana plug
(49)259-20	4	Solder pin
(50)421-22	1	Fuse, 3/4 ampere slow blow

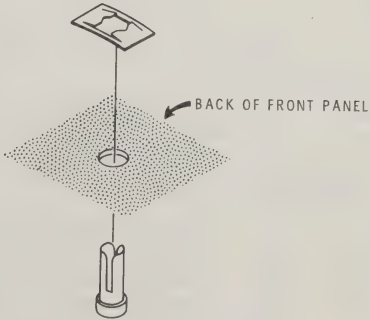
STEP-BY-STEP ASSEMBLY

FRONT AND REAR PANEL SUBASSEMBLIES

Refer to Pictorial 13 for the following steps.

- Place a soft cloth on your work surface to protect the front panel from being scratched in the following steps. Then position the front panel as shown.
- Mount the pilot lamp lens at A as shown in Detail 13A. The lens should be tight against the front of the panel and the speednut pressed down tightly.

NOTE: When you install the binding post bases in the following steps, be sure the hole through each binding post base is in a horizontal position.



Detail 13A

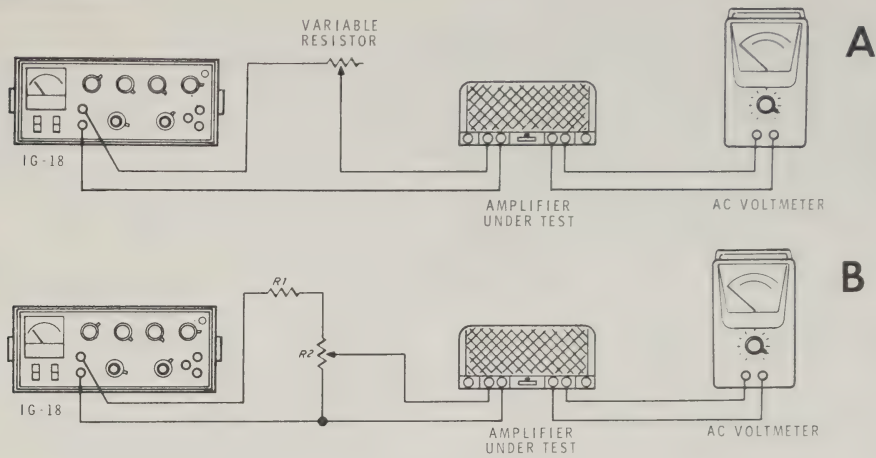
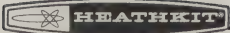


Figure 9

Set the Generator to a low frequency, such as 20 Hz, short out the variable resistor, and set the signal level of the Generator to give a convenient reading on the AC voltmeter. Remove the short from the variable resistor. The value of the variable resistor is then adjusted until the reading on the meter drops to 1/2 of the former value. The resistance of the variable resistor is then equal to the unknown input impedance of the amplifier. The resistance of the variable resistor can be measured with an ohmmeter. If this same check were made at higher frequencies, the input impedance would appear to be smaller because some of the signal would be shorted out by the input capacitance of the amplifier.

For low input impedances, of a few hundred ohms or less, connect the circuit as shown in Figure 9B. Fixed series resistor R1 should be at least ten times the input resistance to be measured. The value of this resistor is not important if it is made large enough. The output voltage is set to some convenient value, as before, with variable resistor R2 disconnected.

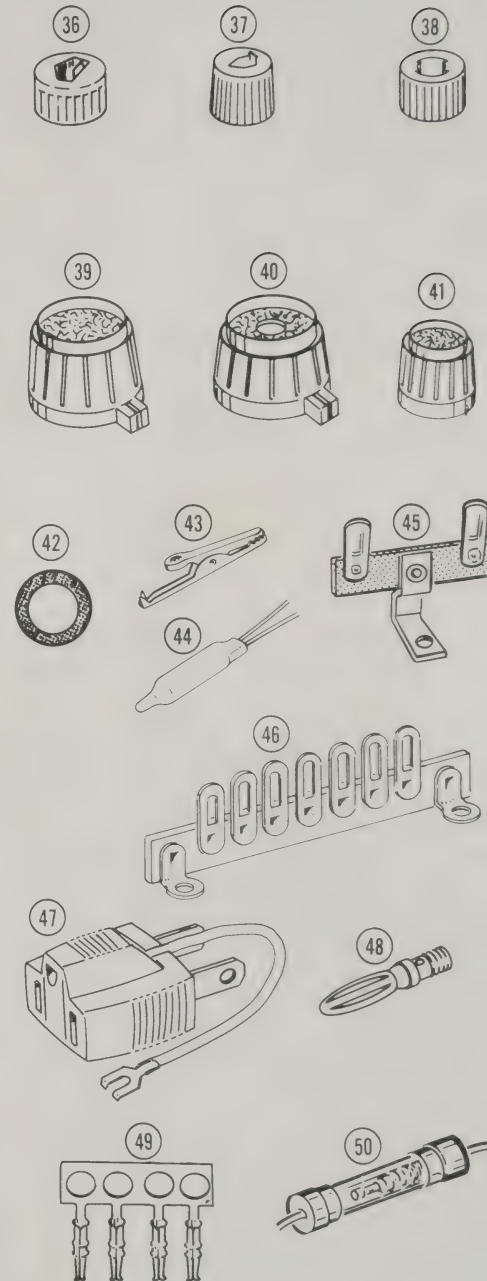
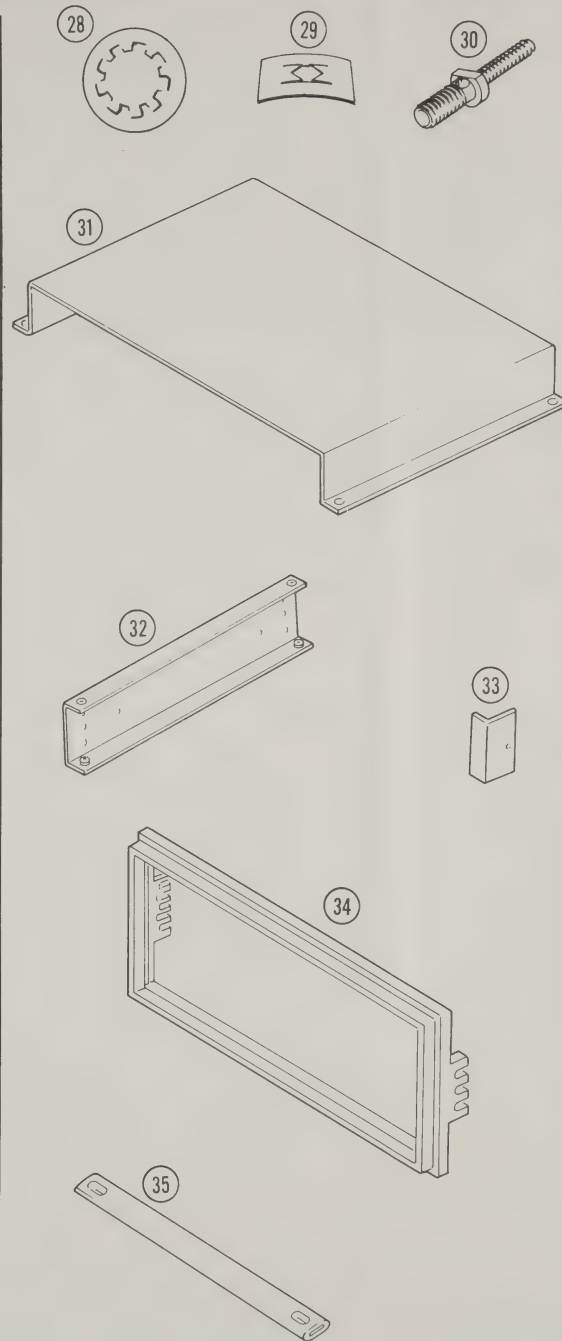
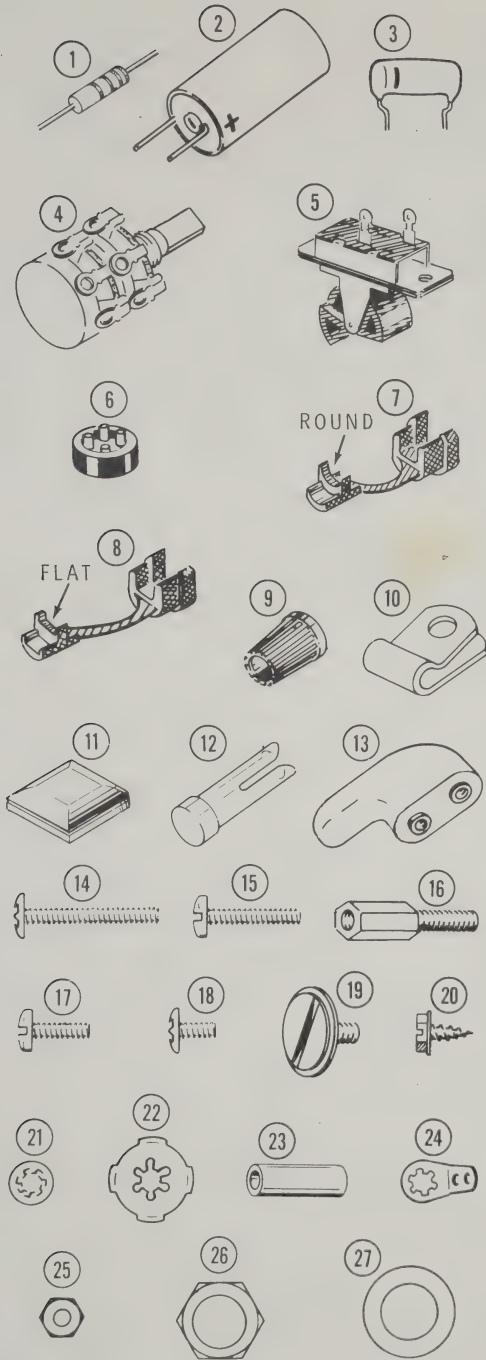
When R2 is connected again, it is adjusted until the meter reading drops to half of the former value. The resistance of variable resistor R2 is then equal to the input resistance of the amplifier.

FREQUENCY MEASUREMENTS

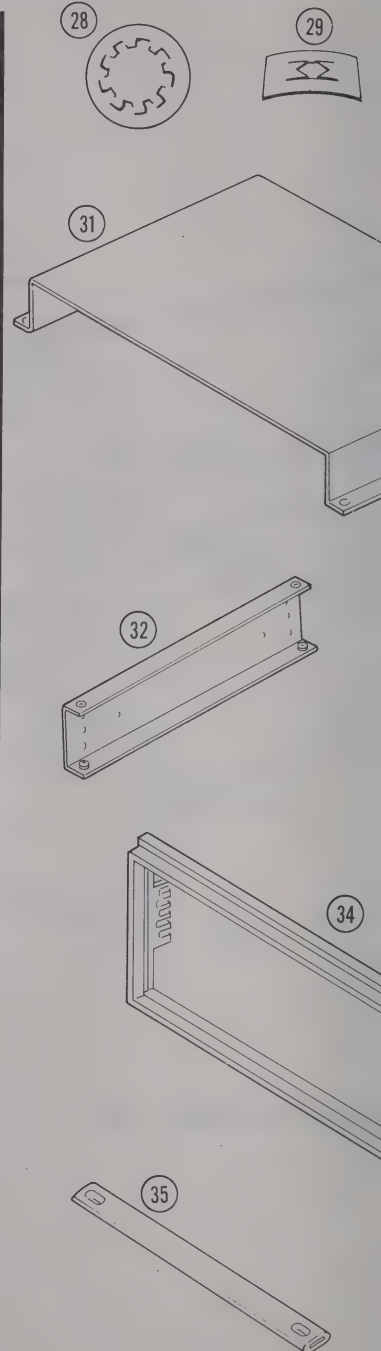
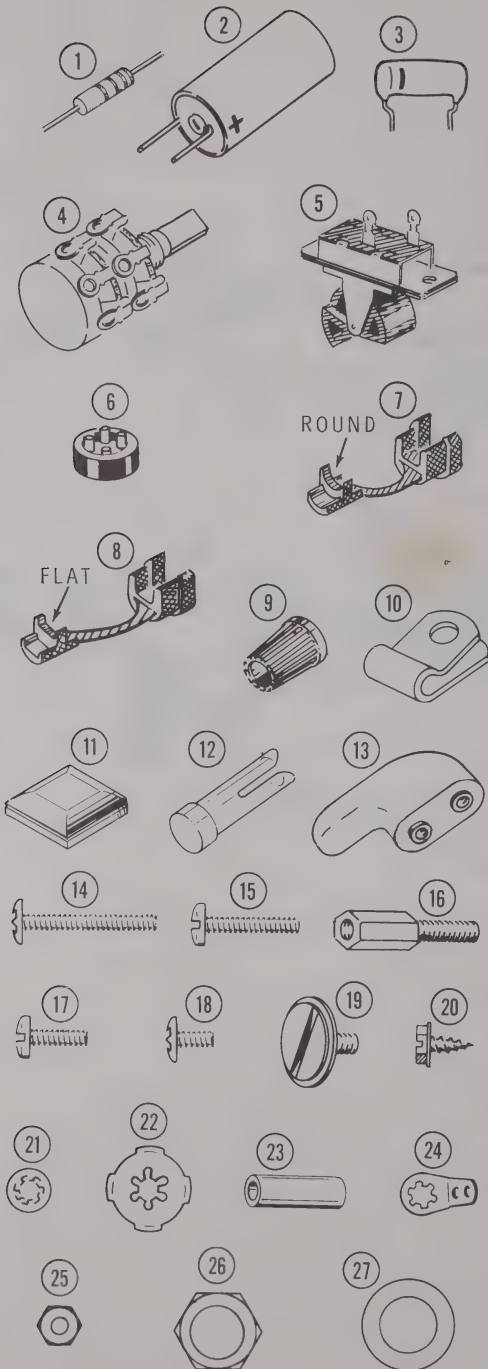
An oscilloscope and the Generator can be used to measure the frequency of an unknown signal. Place the oscilloscope horizontal frequency selector in the horizontal input position. Connect a sine wave from the Generator to the horizontal input of the oscilloscope. Connect the unknown frequency to the vertical input of the oscilloscope. Do not use square waves to make these tests.

When the size of the generator signal is adjusted to approximately the same size as that of the unknown signal, and the oscilloscope is properly adjusted, waveforms called Lissajous figures will be seen on the oscilloscope. Interpreting these waveforms correctly will show the frequency of the unknown signal.

CHASSIS ASSEMBLY PARTS PICTORIAL



CHASSIS ASSEMBLY PARTS

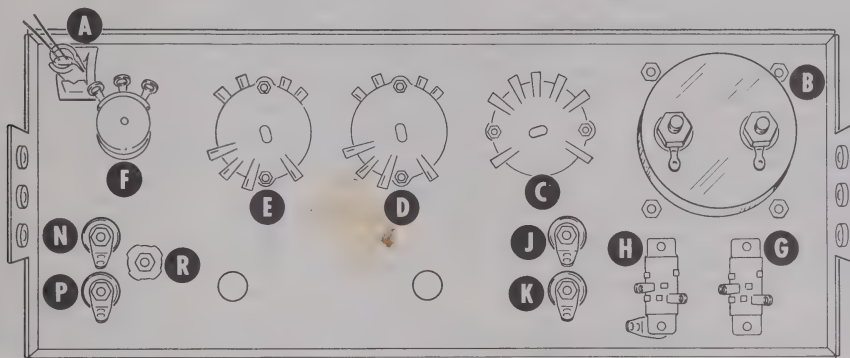


- (✓) Refer to Detail 13G and install the dual control (#12-96) at location F using control hardware.
- (✓) Install the prewired Units Frequency switch (#63-487) (with the white wires) at location E using control hardware.
- (✓) Likewise, install the prewired Tens Frequency switch (#63-487) (with the yellow wires) at location D using control hardware.
- (✓) Install the prewired Multiplier switch (#63-488) at location C with control hardware.

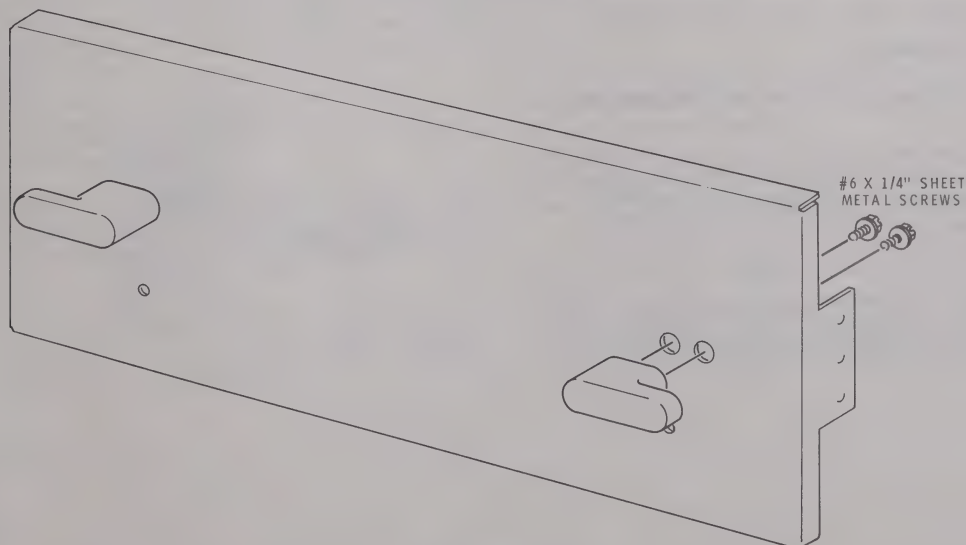
This completes the front panel subassembly. Set it aside until it is called for later.

- (✓) Refer to Pictorial 14 and mount the two line cord retainers on the back (painted side) of the rear panel. Use the four #6 x 1/4" sheet metal screws. Make certain that the shoulders on the retainers fit into the holes in the rear panel.

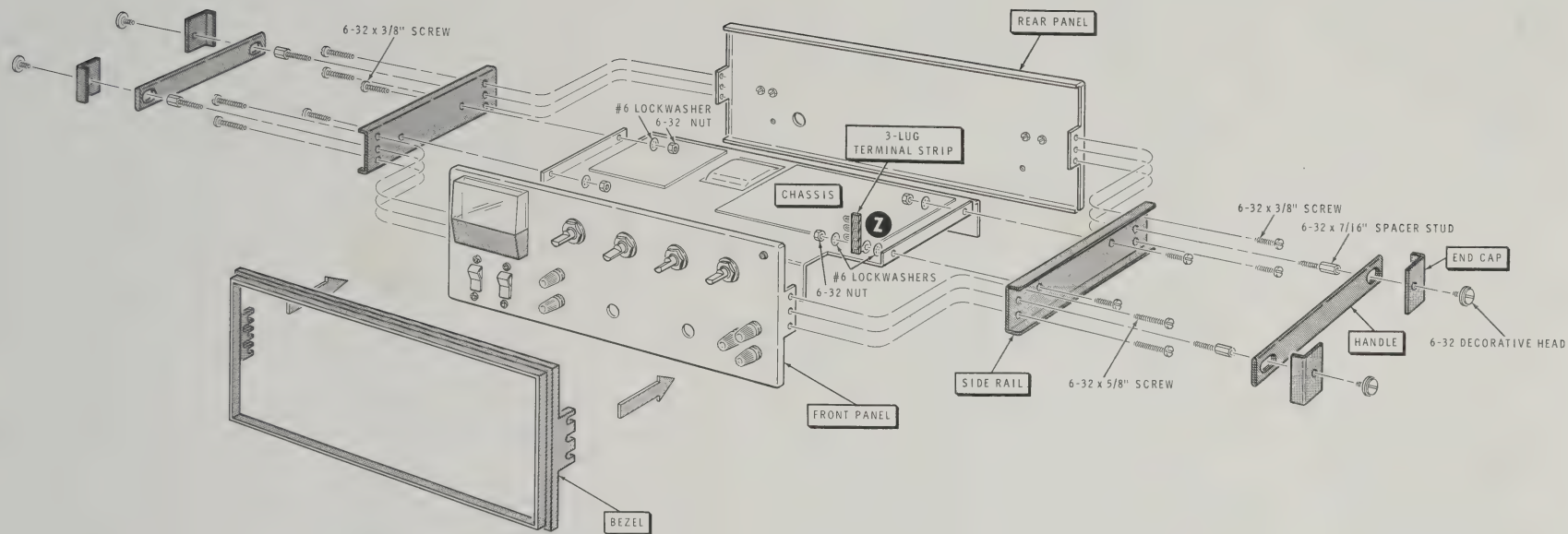
This completes the rear panel subassembly.



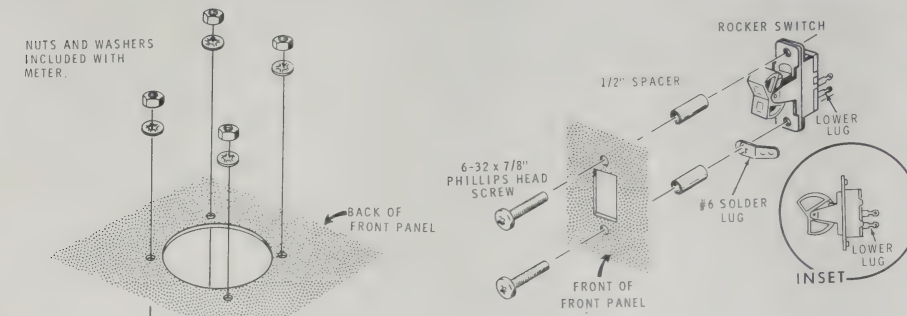
PICTORIAL 13



PICTORIAL 14



PICTORIAL 16



Detail 13F

(✓) Repeat this procedure for another rocker switch to be installed at location G. Do not use a solder lug at this location.

NOTE: Control hardware, in the following four steps, consists of a control lockwasher, a control flat washer, and a control nut. Place the control hardware as shown in Detail 13G and position the controls and switches as shown in Pictorial 13.

Detail 13E

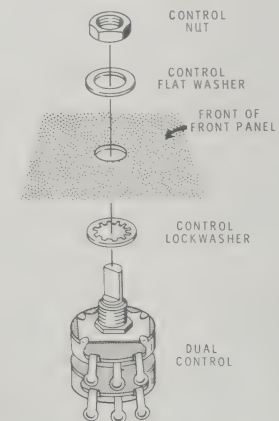
NOTE: When you remove the meter from its carton, use care to avoid pulling off the front cover of the meter.

(✓) Refer to Detail 13E and mount the meter at location B. Use the hardware included in the meter box. Do not overtighten the mounting nuts or you could damage the meter case.

(✓) Remove the shorting wire from between the meter terminals and discard it.

(✓) Position the solder lugs toward the bottom of the instrument and bend them out from the back of the meter as shown in Detail 13E.

(✓) Install a rocker switch (#60-24) at location H using two 6-32 x 7/8" phillips head screws, two 1/2" spacers and one #6 solder lug in the order shown in Detail 13F. Position the switch so that its lower lug is closer to the edge of the front panel than to the panel center.



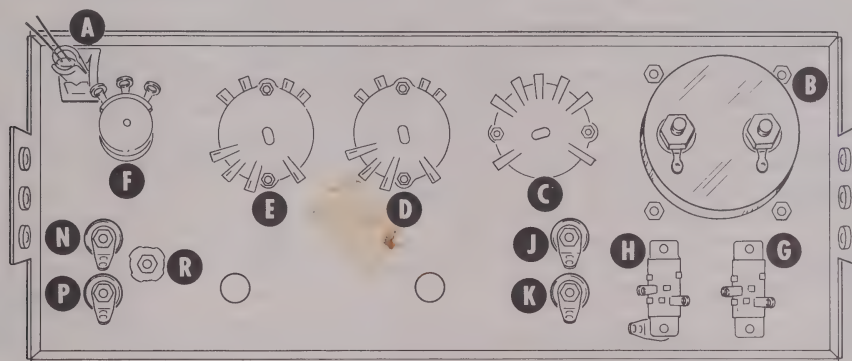
Detail 13G

- (✓) Refer to Detail 13G and install the dual control (#12-96) at location F using control hardware.
- (✓) Install the prewired Units Frequency switch (#63-487) (with the white wires) at location E using control hardware.
- (✓) Likewise, install the prewired Tens Frequency switch (#63-487) (with the yellow wires) at location D using control hardware.
- (✓) Install the prewired Multiplier switch (#63-488) at location C with control hardware.

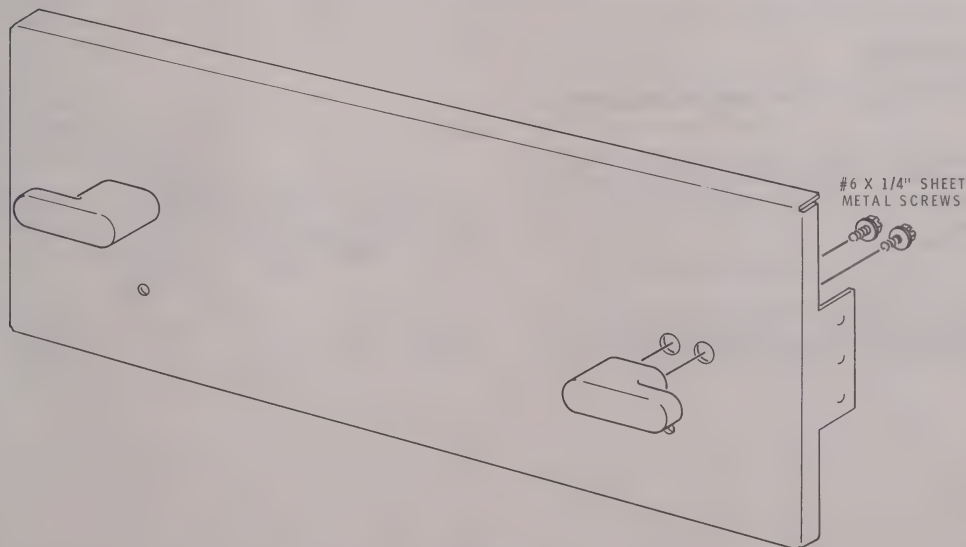
This completes the front panel subassembly. Set it aside until it is called for later.

- (✓) Refer to Pictorial 14 and mount the two line cord retainers on the back (painted side) of the rear panel. Use the four #6 x 1/4" sheet metal screws. Make certain that the shoulders on the retainers fit into the holes in the rear panel.

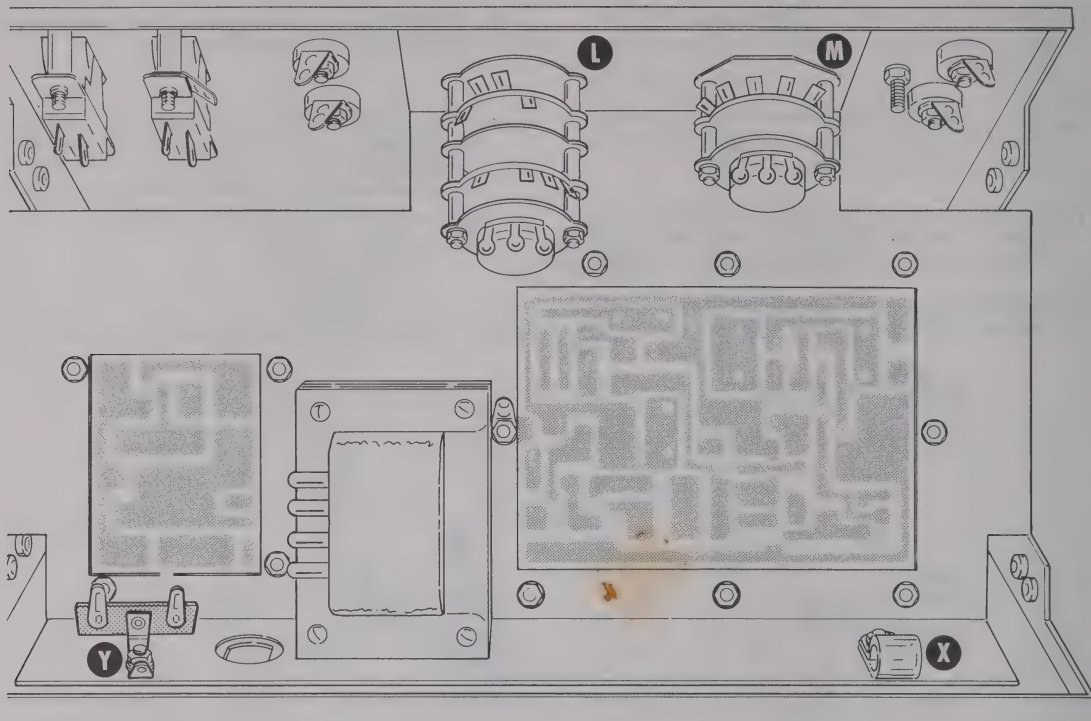
This completes the rear panel subassembly.



PICTORIAL 13



PICTORIAL 14



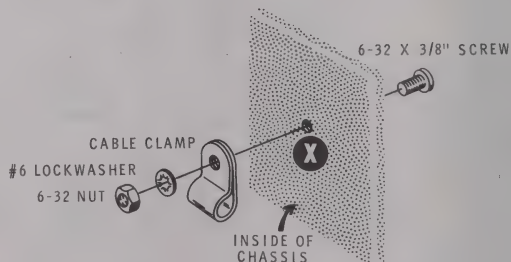
PICTORIAL 15

UNIT ASSEMBLY

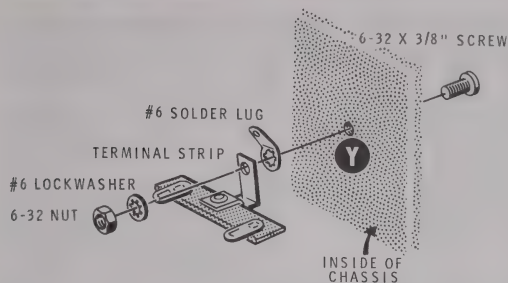
Refer to Pictorial 15 for the following steps.

In the next two steps, fasten the rear panel to the chassis with two 6-32 x 3/8" screws, two #6 lockwashers, one #6 solder lug, and two 6-32 nuts.

- (✓) Mount the cable clamp under the #6 hardware at location X. See Detail 15A. Position the cable clamp as shown in Pictorial 15.



Detail 15A

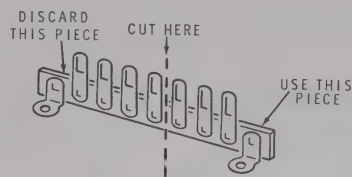


Detail 15B

- (✓) Mount the 2-lug terminal strip under the #6 hardware at location Y. See Detail 15B. Use a #6 solder lug under the terminal strip mounting foot, and a #6 lockwasher under the nut. Position the terminal strip and solder lug as shown in Pictorial 15.
- (✓) Fasten the front panel assembly to the chassis assembly with the Sine Wave Amplitude switch (#63-485) at location L. Use control hardware. Position the switch as shown. Tighten the nut only finger tight at this time.
- (✓) Likewise, install the Square Wave Amplitude switch (#63-486) at location M with control hardware. Position the switch as shown. Now tighten the control nuts at location L and M.

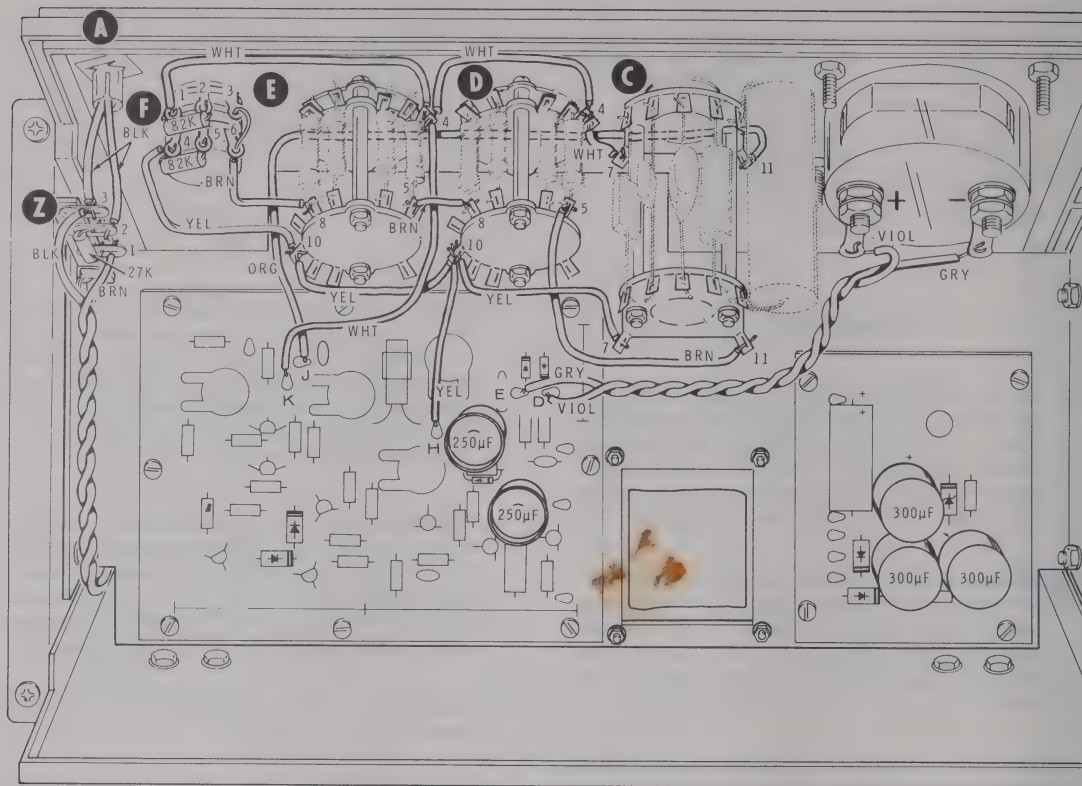
Refer to Pictorial 16 (fold-out from Page 26) for the following steps.

- (✓) Fasten a side rail to the left end of the chassis with two 6-32 x 3/8" screws, two #6 lockwashers, and two 6-32 nuts.
- (✓) Refer to Detail 16A and, with diagonal cutters, cut the 7-lug terminal strip as shown.



Detail 16A

- (✓) Likewise, fasten a side rail to the right end of the chassis with a 3-lug terminal strip at Z. Use two 6-32 x 3/8" screws, three #6 lockwashers, and two 6-32 nuts. Notice that a #6 lockwasher is used on both sides of the terminal strip mounting foot. Position the terminal strip as shown.
- (✓) Mount the bezel over the front panel. Fit the bezel side flanges into the space between the front panel flanges and the side rails. Secure the bezel with two 6-32 x 5/8" screws through each side rail. Thread the screws into the press-nuts in the front panel flanges.
- (✓) Fasten one side rail to the rear panel with two 6-32 x 3/8" screws.
- (✓) Likewise, fasten the other side rail to the rear panel with 6-32 x 3/8" screws.
- (✓) Install the four 6-32 x 7/16" spacer studs through the side rails and into the front and rear panel flanges.
- (✓) Remove the tape from the ends of a handle. Position the handle over the two spacer studs on one end of the instrument. Secure the handle in place with two end caps and two 6-32 decorative head screws.
- (✓) In the same way, mount the handle, end caps, and decorative head screws on the other end of the instrument.



PICTORIAL 17

TOP CHASSIS WIRING

Refer to Pictorial 17 for the following steps.

(L) Position the Generator as shown.

(L) Prepare an 8' violet and an 8' gray hook-up wire. Twist these two wires to form a twisted pair.

() At one end of this twisted pair, connect the gray wire to the negative (-) lug (S-1) and the violet wire to the positive (+) lug (S-1) of the meter.

(L) At the other end of this twisted pair, connect the violet wire to hole D (S-1) and the gray wire to hole E (S-1) on the generator circuit board. Route the twisted pair close to the chassis as shown.

() Connect the orange wire coming from lug F11 of switch C to hole J on the generator circuit board (S-1). Route the wire as shown.

() Connect the white wire coming from lug F7 of switch C to lug F4 of switch D (NS).

Connect the three white wires coming from lug F4 of switch E as directed in the next three steps.

() Connect the longest white wire to lug 1 of control F (NS).

() Connect the next longest white wire to lug F4 of switch D (S-2).

() Connect the remaining white wire to hole K on the generator circuit board (S-1).

Connect the three yellow wires coming from lug R10 of switch D as directed in the following three steps:

- (✓) The longest yellow wire to lug R7 of switch C (S-1).
- (✓) The next longest yellow wire to lug R10 of switch E (NS). Route this wire under the white wire.
- (✓) The remaining yellow wire to hole H on the generator circuit board (S-1).

(✓) Connect the brown wire coming from lug R5 of switch D to lug R11 of switch C (S-1).

(✓) Connect the brown wire coming from lug R5 of switch E to lug R8 of switch D (S-3).

(✓) Pass the stripped end of the brown wire coming from lug 8 of switch E through lug 6 (S-2) to lug 3 (S-1) of control F.

(✓) Connect an 82 k Ω (gray-red-orange) resistor from lug 1 (S-2) to lug 2 (S-1) of control F.

(✓) Connect an 82 k Ω (gray-red-orange) resistor from lug 4 (NS) to lug 5 (S-1) of control F.

(✓) Connect a 27 k Ω (red-violet-orange) resistor from lug 1 (NS) to lug 2 (NS) of terminal strip Z.

(✓) Prepare the following lengths of hookup wire:

3-1/2" yellow
17" black
17" brown

(✓) Connect a 3-1/2" yellow wire from lug 4 of control F (S-2) to lug R10 of switch E (S-2). Be sure to solder both lugs at R10.

(✓) Twist the 17" black and the 17" brown wires together to form a twisted pair.

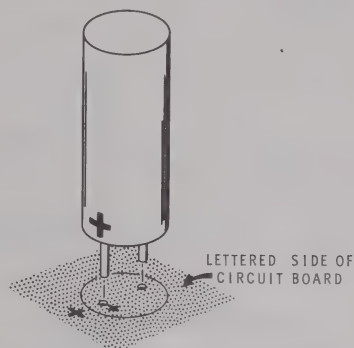
(✓) Pass one end of this twisted pair through the opening at the rear of the chassis as shown. This end will be connected later.

() At the other end of this twisted pair, connect the brown wire to lug 1 (S-2) and the black wire to lug 3 (NS) of terminal strip Z.

(✓) Locate the neon lamp and insert it into the pilot lamp lens.

(✓) Strip 3" of insulation from a piece of brown hookup wire and cut it in half.

(✓) Place a 1-1/2" piece of insulation on each of the pilot lamp leads. Then connect one lead to lug 2 (S-2) and the other lead to lug 3 (S-2) of terminal strip Z.



Detail 17A

NOTE: Always mount electrolytic capacitors so the positive (+) mark on the capacitor matches the positive (+) mark on the circuit board. See Detail 17A. Bend the leads slightly to hold the capacitors in place until they are soldered.

(✓) Mount the two 250 μ F electrolytic capacitors on the generator circuit board as shown.

(✓) Mount the three 300 μ F electrolytic capacitors on the power supply circuit board.

(✓) Solder all connections to the foil and cut off the excess lead lengths.

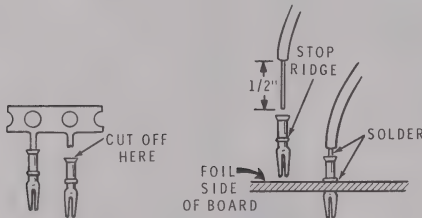
NOTE: Both circuit boards are now complete, however, you will notice four open holes in the power supply circuit board. These holes are not used.



BOTTOM CHASSIS WIRING

Refer to Pictorial 18 (fold-out from Page 35) for the following steps.

- (✓) Position the Generator upside down as it is shown in the Pictorial.
- (✓) Pass the black and brown twisted pair through the cable clamp at X and route them along the rear of the chassis as shown.
- (✓) Connect the black wire of this twisted pair to lug 4 (NS) and the brown wire to lug 2 (NS) of the power transformer.



Detail 18A

Refer to Detail 18A and use the following steps when connecting a wire to the foil side of a circuit board.

1. Cut a solder pin from its support.
2. Insert the pin into the circuit board as far as the stop ridge.
3. Strip a total of 1/2" of insulation from the wire.
4. Insert the wire into the solder pin.

CAUTION: Leave enough space between the insulation and the top of the solder pin so the solder can flow into the pin and around the wire.

5. Solder the pin to the foil and the wire to the pin.
- (✓) Using a solder pin, connect the longer black wire coming from lug 2 of switch M to circuit board hole L (S-1).
- (✓) Connect the remaining black wire coming from lug 2 of switch M to solder lug P (S-1).

- (✓) Connect the green wire coming from lug 3 of switch M to solder lug N (S-1).
- (✓) Connect the blue wire coming from lug F6 on switch L to solder lug J (NS).
- (✓) Connect a 560 Ω (green-blue-brown) resistor from solder lug J (S-2) to lug 1 of switch H (S-1).
- (✓) Connect the lead from the banded end of a .047 μ F Mylar capacitor to the #6 solder lug on switch H (S-1) as shown.
- (✓) Connect the other end of this capacitor to solder lug K (NS).
- (✓) Connect the black wire coming from lug F5 of switch L to solder lug K (NS).
- (✓) Connect a 5-1/4" black wire from solder lug K (S-3) to location AB (not screened) on the circuit board. Solder this wire directly to the foil of the circuit board.
- (✓) Connect the blue wire coming from lug F4 of switch L to lug 2 of switch H (S-1).
- (✓) Using a solder pin, connect the 620 Ω (blue-red-brown) resistor coming from lug R2 of switch L to circuit board hole G (S-1). Make sure the lead does not touch the switch frame.
- (✓) Using a solder pin, connect the blue wire coming from lug 3 of control L to circuit board hole F (S-1).
- (✓) Prepare the following lengths of hookup wire:
 - 5" green, strip of 1/2" of insulation from one end.
 - 8" black
 - 8" brown
- (✓) Using a solder pin, connect a 5" green wire from lug 3 of control M (S-1) to circuit board hole B (S-1).
- (✓) Twist together the 8" black and the 8" brown wires to form a twisted pair.
- (✓) At one end of this twisted pair, connect the brown wire to lug 1 (S-1) and the black wire to lug 2 (S-1) of switch G.

- (✓) At the other end of this twisted pair, connect the black wire to lug 2 (NS) of terminal strip Y.

- (✓) Connect the brown wire to lug 1 of the power transformer (NS).

NOTE: A flat 3-lead line cord is supplied with this kit that is approved for use in the U.S.A. and in some other countries. If this cord is not approved for your locality, obtain locally an approved cord and proceed with the following steps, making changes where necessary.

The flat 3-lead line cord supplied with this kit has one of its outer leads marked with ribs in the insulation along its edge. The other lead is smooth, and the third lead is color coded green.

- (✓) Separate the three line cord leads for a distance of about 1-1/2" from the stripped ends. Twist together and apply a small amount of solder to the small wires at the end of each lead. This will hold the separate strands together.

- (✓) Pass the line cord through the hole in the rear panel.

- (✓) Connect the green line cord lead to the solder lug of Y (S-1).

- (✓) Connect the ribbed line cord lead to lug 4 of the power transformer (NS).

- (✓) Connect the smooth line cord lead to lug 1 of terminal strip Y (NS).

- (✓) Connect one lead of the fuse to lug 1 of terminal strip Y (S-2).

- (✓) Connect the other fuse lead to lug 2 of terminal strip Y (S-2).

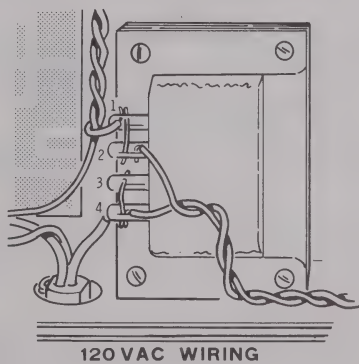
120-240 VAC WIRING ALTERNATIVE

Two sets of line voltage wiring instructions are given below: one for 120 VAC line voltage, and the other for 240 VAC line voltage on Page 34. In the U.S.A., 120 VAC is most commonly used, while in some other countries 240 VAC is more common. **USE ONLY THE INSTRUCTIONS THAT AGREE WITH THE LINE VOLTAGE IN YOUR AREA.**

120 VAC Wiring

Refer to Detail 18B for the following steps.

- (✓) Remove the insulation from two 1" lengths of hookup wire.
- (✓) Connect a 1" bare wire from lug 1 (S-2) to lug 2 (S-2) of the power transformer.
- (✓) Connect a 1" bare wire from lug 3 (S-1) to lug 4 (S-3) of the power transformer.



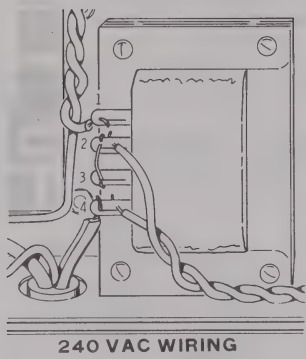
Detail 18B



240 VAC Wiring

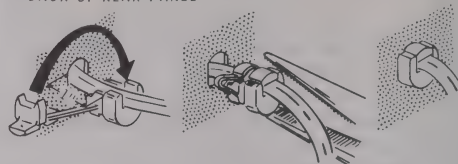
Refer to Detail 18C for the following steps.

- () Remove the insulation from a 1" length of hookup wire.
- () Connect a 1" bare wire from lug 2 (S-2) to lug 3 (S-1) of the power transformer.
- () Solder transformer lug 1 (S-1).
- () Solder transformer lug 4 (S-2).



Detail 18C

BACK OF REAR PANEL



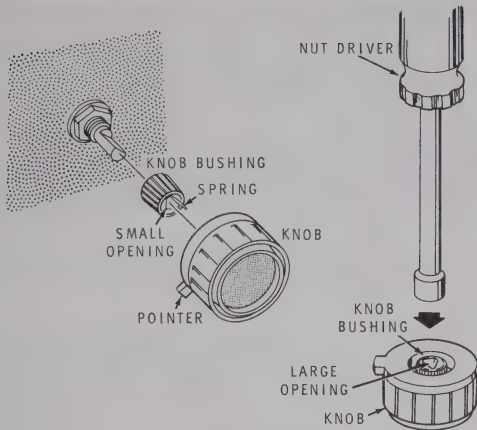
1. PULL SLACK OUT OF CORD.
2. CRIMP STRAIN RELIEF ON CORD ABOUT ONE INCH FROM REAR PANEL.
3. COMPRESS STRAIN RELIEF SO THAT IT WILL PASS INTO HOLE IN REAR PANEL. LINE-UP FLATS ON STRAIN RELIEF WITH STRAIGHT SIDES OF HOLE.
4. PULL LINE CORD ON INSIDE OF INSTRUMENT TO EXPAND STRAIN RELIEF.

Detail 18D

NOTE: In the following step, if you have used the flat 3-lead line cord supplied with this kit, install strain relief #75-71. If you have used a round line cord (not supplied with this kit), install strain relief #75-30.

Refer to Detail 18D and install the line cord strain relief on the line cord.

This completes the wiring of your Heathkit Sine-Square Audio Generator. Carefully inspect all solder joints for unsoldered wires or loose connections. Remove any wire clippings or solder splashes that may be lodged in the wiring. Then proceed to the Knob Installation section.



Detail 19A

KNOB INSTALLATION

The knobs supplied with this kit use knob bushings that provide permanent positive gripping without the use of setscrews. Perform the following steps carefully since it is very difficult to remove a knob bushing from a knob once it is fully inserted. Each knob will be made to align with particular switch markings. Whenever you remove a knob, be sure to replace it on the same shaft. Refer to Pictorial 19 (fold-out from Page 36) for switch and control locations.

Single Knob Installation

Refer to Detail 19A for the following steps.

- () Push single knob bushings (#455-50) onto the multiplier switch shaft, the two frequency switch shafts, and the frequency control shaft. Then turn all shafts to their full counterclockwise position.
- () At one of the switch locations, line up the pointer of a single knob with the full counterclockwise marking on the panel. Then press the knob slightly onto the knob bushing.

- () Turn the knob clockwise to each of the switch stop positions. Check to see that the pointer lines up with each panel marking.

NOTE: Perform the next three steps only if the pointer does not line up at each switch marking.

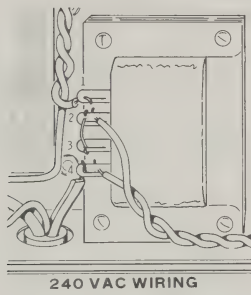
1. () Turn the knob pointer to the mid-position marking on the panel.
2. () Remove the knob from the bushing and turn it slightly to line up the pointer with the midposition marking.
3. () Press the knob slightly onto the knob bushing. Then turn the knob to each switch position and recheck the pointer alignment. If more than a slight error is noticed at either end position, repeat these three steps.

- () Carefully remove the knob and bushing assembly.
- () Place the assembly on a table or other hard surface; then press the bushing firmly and completely into the knob.
- () Press the knob and bushing assembly firmly onto the switch shaft.
- () Repeat the above Knob Installation steps to install knobs on the remaining switch shafts.
- () Turn the Frequency control shaft fully counterclockwise and set the knob pointer at zero.
- () Repeat the above Knob Installation steps for the installation of the Frequency control knob.

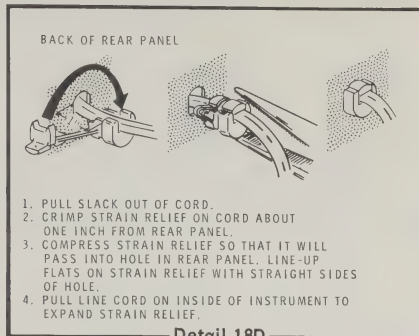
240 VAC Wiring

Refer to Detail 18C for the following steps.

- () Remove the insulation from a 1" length of hookup wire.
- () Connect a 1" bare wire from lug 2 (S-2) to lug 3 (S-1) of the power transformer.
- () Solder transformer lug 1 (S-1).
- () Solder transformer lug 4 (S-2).



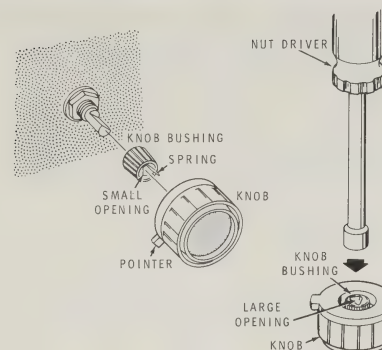
Detail 18C



NOTE: In the following step, if you have used the flat 3-lead line cord supplied with this kit, install strain relief #75-71. If you have used a round line cord (not supplied with this kit), install strain relief #75-30.

Refer to Detail 18D and install the line cord strain relief on the line cord.

This completes the wiring of your Heathkit Sine-Square Audio Generator. Carefully inspect all solder joints for unsoldered wires or loose connections. Remove any wire clippings or solder splashes that may be lodged in the wiring. Then proceed to the Knob Installation section.



Detail 19A

KNOB INSTALLATION

The knobs supplied with this kit use knob bushings that provide permanent positive gripping without the use of setscrews. Perform the following steps carefully since it is very difficult to remove a knob bushing from a knob once it is fully inserted. Each knob will be made to align with particular switch markings. Whenever you remove a knob, be sure to replace it on the same shaft. Refer to Pictorial 19 (fold-out from Page 36) for switch and control locations.

Single Knob Installation

Refer to Detail 19A for the following steps.

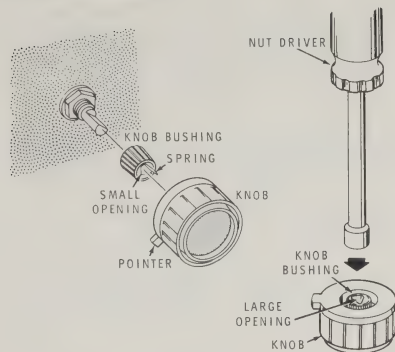
- () Push single knob bushings (#455-50) onto the multiplier switch shaft, the two frequency switch shafts, and the frequency control shaft. Then turn all shafts to their full counterclockwise position.
- () At one of the switch locations, line up the pointer of a single knob with the full counterclockwise marking on the panel. Then press the knob slightly onto the knob bushing.

- () Turn the knob clockwise to each of the switch stop positions. Check to see that the pointer lines up with each panel marking.

NOTE: Perform the next three steps only if the pointer does not line up at each switch marking.

1. () Turn the knob pointer to the mid-position marking on the panel.
2. () Remove the knob from the bushing and turn it slightly to line up the pointer with the midposition marking.
3. () Press the knob slightly onto the knob bushing. Then turn the knob to each switch position and recheck the pointer alignment. If more than a slight error is noticed at either end position, repeat these three steps.

- () Carefully remove the knob and bushing assembly.
- () Place the assembly on a table or other hard surface; then press the bushing firmly and completely into the knob.
- () Press the knob and bushing assembly firmly onto the switch shaft.
- () Repeat the above Knob Installation steps to install knobs on the remaining switch shafts.
- () Turn the Frequency control shaft fully counterclockwise and set the knob pointer at zero.
- () Repeat the above Knob Installation steps for the installation of the Frequency control knob.



Detail 19A

KNOB INSTALLATION

The knobs supplied with this kit use knob bushings that provide permanent positive gripping without the use of setscrews. Perform the following steps carefully since it is very difficult to remove a knob bushing from a knob once it is fully inserted. Each knob will be made to align with particular switch markings. Whenever you remove a knob, be sure to replace it on the same shaft. Refer to Pictorial 19 (fold-out from Page 36) for switch and control locations.

Single Knob Installation

Refer to Detail 19A for the following steps.

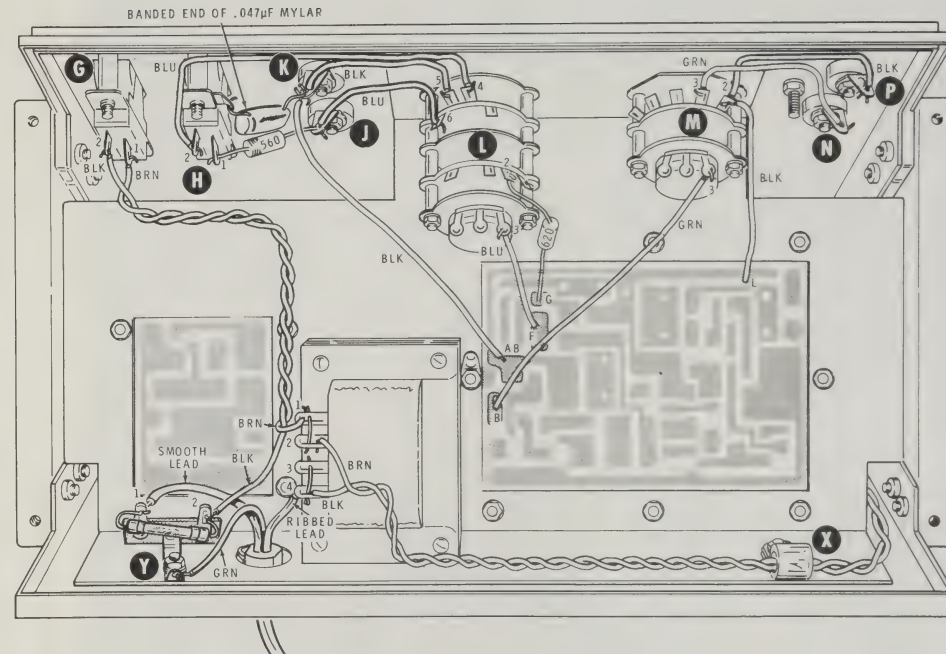
- () Push single knob bushings (#455-50) onto the multiplier switch shaft, the two frequency switch shafts, and the frequency control shaft. Then turn all shafts to their full counterclockwise position.
- () At one of the switch locations, line up the pointer of a single knob with the full counterclockwise marking on the panel. Then press the knob slightly onto the knob bushing.

- () Turn the knob clockwise to each of the switch stop positions. Check to see that the pointer lines up with each panel marking.

NOTE: Perform the next three steps only if the pointer does not line up at each switch marking.

1. () Turn the knob pointer to the mid-position marking on the panel.
2. () Remove the knob from the bushing and turn it slightly to line up the pointer with the midposition marking.
3. () Press the knob slightly onto the knob bushing. Then turn the knob to each switch position and recheck the pointer alignment. If more than a slight error is noticed at either end position, repeat these three steps.

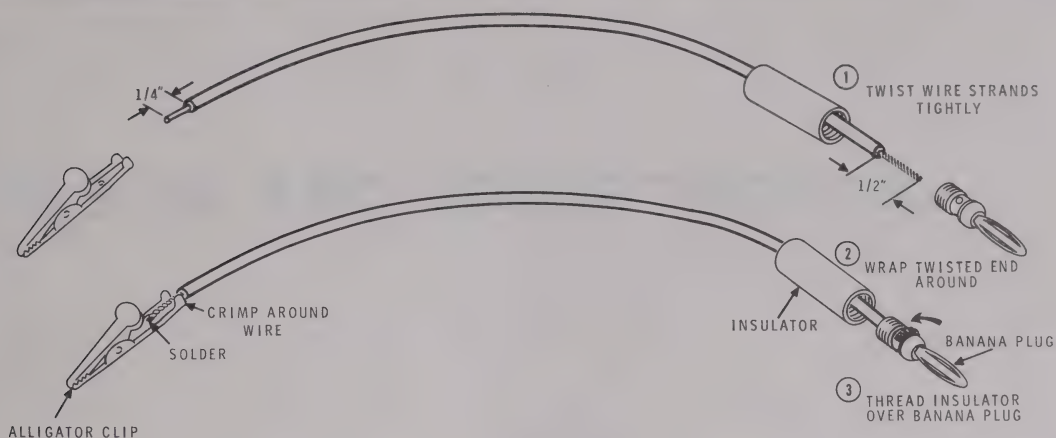
- () Carefully remove the knob and bushing assembly.
- () Place the assembly on a table or other hard surface; then press the bushing firmly and completely into the knob.
- () Press the knob and bushing assembly firmly onto the switch shaft.
- () Repeat the above Knob Installation steps to install knobs on the remaining switch shafts.
- () Turn the Frequency control shaft fully counterclockwise and set the knob pointer at zero.
- () Repeat the above Knob Installation steps for the installation of the Frequency control knob.



PICTORIAL 18



PICTORIAL 18



PICTORIAL 20

TEST LEAD ASSEMBLY

- () Prepare both ends of the red and black test leads as shown in Pictorial 20. Fasten an alligator clip on one end and a banana plug on the other end of each test lead. Do not

solder the wire ends that go into the banana plug.

This completes the Step-By-Step Assembly. Proceed to the Tests And Adjustments.

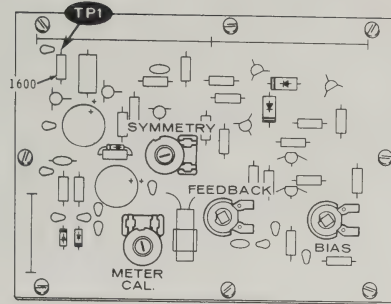
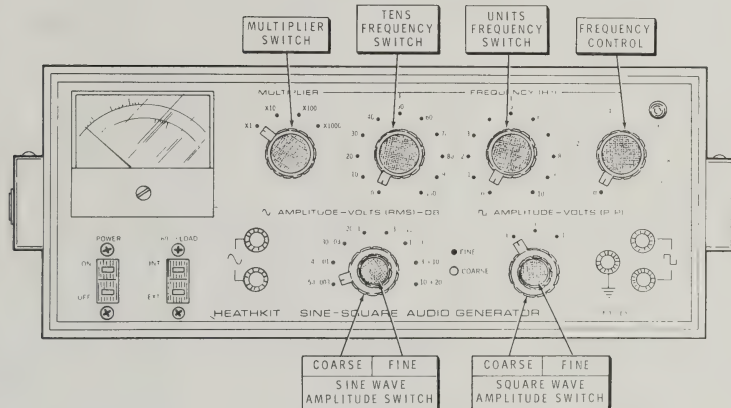
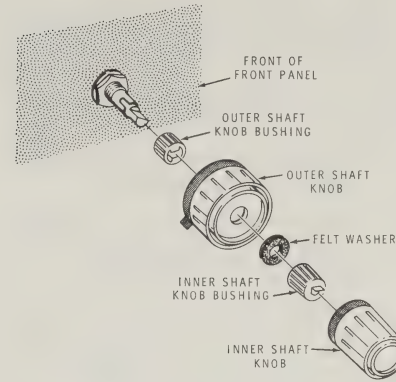


FIGURE 1



PICTORIAL 19



Detail 19B

Dual Knob Installation

In the following steps, the pointer on each knob will be lined up with a specific mark on the front panel. Whenever you remove any knob, be sure you replace it on the control shaft from which it was removed.

CAUTION: Look very carefully at each outer shaft knob bushing (#455-52) before you perform the following steps. Note that the bushing has a round hole at one end and a "keyed hole" at the other end. Be sure you place the bushing on the outer shafts of the switches so the round hole is toward the panel.

- () Refer to Detail 19B and place an outer shaft knob bushing (round hole toward the panel) on the outer shafts of the Sine Wave Amplitude and Square Wave Amplitude switches. Then turn both switch shafts to their full counterclockwise positions.

- () Line up the pointer of an outer shaft knob with the -50.003 position of the Sine wave Amplitude switch, and press the knob part way onto the bushing.

- () Carefully remove the knob and bushing assembly and press the bushing all the way into the knob.

- () Replace the knob-bushing assembly on the switch shaft.

- () Repeat the last three steps for the Square Wave Amplitude switch. Align the knob pointer with the $.1$ volt switch position.

- () Refer to Detail 19B and push an inner shaft knob bushing (#455-51) onto each of the small control shafts of the Sine Wave Amplitude and Square Wave Amplitude controls. Then turn the control shafts to their full counterclockwise positions.

- () Line up the pointer mark of an inner shaft knob at the 7 o'clock position; then press the knob part way onto the bushing.

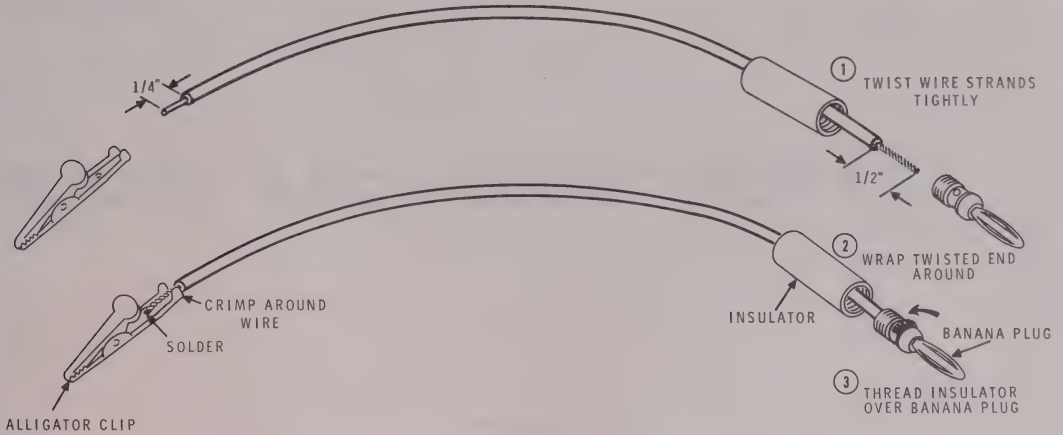
- () Carefully remove the knob and bushing assembly and press the bushing all the way into the knob.

- () Before replacing the knob bushing assembly, place a felt washer on the inner shaft in front of the outer shaft knob.

- () Replace the knob-bushing assembly onto the inner shaft as far as it will go.

- () Repeat the above five steps for the other inner shaft knob and bushing.

This completes the Knob Installation.



PICTORIAL 20

TEST LEAD ASSEMBLY

() Prepare both ends of the red and black test leads as shown in Pictorial 20. Fasten an alligator clip on one end and a banana plug on the other end of each test lead. Do not

solder the wire ends that go into the banana plug.

This completes the Step-By-Step Assembly. Proceed to the Tests And Adjustments.

TESTS AND ADJUSTMENTS

TESTS

If you do not obtain the correct results in any of the following tests, turn the equipment off. Then refer to the chart following the step. These charts list the Condition of the malfunction, and the Possible Cause. Review the items listed in the Possible Cause column and correct the condition before proceeding to the next step. The information in the In Case Of Difficulty section (Page 57) of the Manual may also be helpful in locating trouble in the kit.

Refer to Figure 1 (on fold-out from Page 36) for the following step.

- () Connect the common lead of an ohmmeter to either black binding post of the Generator. Connect the other ohmmeter lead to test-point (TP1) on the wave generator circuit board. The ohmmeter should indicate a resistance of at least 1500 Ω , when the pointer stops.

DIFFICULTY	POSSIBLE CAUSE
Resistance measured considerably less than 1500 Ω .	Short circuit on wave generator circuit board: 1. Check positioning of transistors. 2. Check values of resistors. 3. Check for solder bridges between circuit board foils.
Resistance measured considerably more than 1500 Ω .	Open circuit(s) on wave generator circuit board: 1. Check solder connections. 2. Check resistor values. 3. Check for broken component leads.

- () Measure the resistance between the two flat prongs of the AC line cord plug. With the POWER switch off, the resistance should read infinite. With the POWER switch on, the resistance should be 20 Ω or more.

DIFFICULTY	POSSIBLE CAUSE
Resistance measured 20 Ω or more with POWER switch off and infinite with POWER switch on.	POWER switch installed upside down.
Resistance measured near zero ohms.	POWER switch connected directly across line cord.

- () Check the resistance between each line cord plug prong and the chassis. The resistance should measure infinite for both prongs.

- () Check the resistance between the round ground prong of the line cord plug and the chassis. This resistance should be near zero ohms.

DIFFICULTY	POSSIBLE CAUSE
Resistance not as described.	Line cord not wired properly. Check line cord connections.

- | | |
|---|--|
| <p>() Set the voltmeter to read a DC+ voltage of about 43 volts.</p> <p>() Connect the voltmeter common lead to either black binding post. Connect the other voltmeter lead to TP1.</p> | <p>() Turn the POWER switch OFF, and plug the line cord into a 120 VAC outlet.</p> <p>() Turn the POWER switch ON. The voltmeter reading should gradually increase to about 43 volts and stay there.</p> |
|---|--|

DIFFICULTY	POSSIBLE CAUSE
Measured voltage less than 43 VDC but more than zero.	1. Diode D5 or D6 installed backwards. 2. Poor solder connections. 3. Capacitors C1, C2, C3, or C4 installed backwards.
No voltage.	1. Transistor improperly installed. 2. Open circuit or short circuit on power supply circuit board.
Measured voltage about 50 volts.	1. Zener diode D7.

() Turn the POWER switch off.

This concludes the tests. Proceed to the Adjustments.

ADJUSTMENTS

Two methods for adjusting the Audio Generator are provided below. The first method uses only an AC voltmeter, and the second method (on Page 42) uses an AC voltmeter and an oscilloscope. Use the second method if you intend to use the Audio Generator with an oscilloscope. This will enable you to adjust the square wave Symmetry control, which cannot be done effectively with only a voltmeter.

ADJUSTMENTS WITH AC VOLTMETER ONLY

Set the switches and controls as follows:

() POWER SWITCH: OFF.

() MULTIPLIER: X10.

() TENS FREQUENCY: 10.

() UNITS FREQUENCY: 0.

() FREQUENCY control: 0.

NOTE: The word FINE on the front panel refers to the small knob on each of the AMPLITUDE controls. COARSE refers to the large knob on each of the AMPLITUDE switches.

() SINE WAVE AMPLITUDE switch (coarse): 10 volts.

() SINE WAVE AMPLITUDE control (fine): Fully clockwise.

() SQUARE WAVE AMPLITUDE switch (coarse): 10 volts.

() SQUARE WAVE AMPLITUDE control (fine): Fully clockwise.

() 600 Ω LOAD SWITCH: EXT.

NOTE: The following controls are located on the wave generator circuit board. Refer to Figure 1 for their location. Position each control at its center of rotation.

() BIAS.

() FEEDBACK.

() SYMMETRY.

() METER CAL.

- () Plug the line cord into an AC outlet.
- () Turn the POWER switch ON.
- () Adjust the FEEDBACK control until the panel meter reads between 6 and 8 on the 0-10 scale.
- () Set the external voltmeter to read 10 volts AC.
- () Connect the external voltmeter common lead to the black sine wave output binding post. Connect the other voltmeter lead to the red sine wave output binding post.
- () Rotate the METER CAL control clockwise until the panel meter reads the same, on the 0-10 scale, as the voltmeter.
- () Disconnect the external voltmeter.

NOTE: During the following adjustments the panel meter pointer may seem to vary erratically. This is normal. If you encounter difficulties, make the control adjustments in small increments and allow the instrument time to stabilize after each adjustment.

- () Turn the SINE WAVE AMPLITUDE control (fine) to approximately the 3 o'clock position.
- () Adjust the BIAS control until you obtain a maximum panel meter reading.
- () Turn the SINE WAVE AMPLITUDE (fine) control fully clockwise.
- () Adjust the FEEDBACK control until the panel meter reads 10 volts.

NOTE: In the following two steps, if no change can be detected in the panel meter reading, it will not be necessary to readjust the feedback control.

- () Turn the TENS FREQUENCY switch to each position, 10 through 100. Leave the switch in the position where the panel meter indicates the lowest voltage.
- () Turn the MULTIPLIER switch to each position, X1 through X1000. Leave the switch in the position where the panel meter indicates the lowest voltage.

- () Readjust the FEEDBACK control until the panel meter indicates 10 volts.

This completes the adjustments of the Audio Generator. Turn off the power and remove the AC plug from the socket. Proceed with the Final Assembly on Page 45.

ADJUSTMENTS WITH AC VOLTMETER AND OSCILLOSCOPE

Set the controls and switches as follows:

- () POWER SWITCH: OFF.
- () MULTIPLIER: X100.
- () TENS FREQUENCY: 10.
- () UNITS FREQUENCY: 0.
- () FREQUENCY control: 0.

NOTE: The word FINE on the front panel refers to the small knob on each of the AMPLITUDE controls. COARSE refers to the large knob on each of the AMPLITUDE switches.

- () SINE WAVE AMPLITUDE switch (coarse): 10 volts.
- () SINE WAVE AMPLITUDE control (fine): Fully clockwise.
- () SQUARE WAVE AMPLITUDE switch (coarse): 10 volts.
- () SQUARE WAVE AMPLITUDE control (fine): Fully clockwise.
- () 600 Ω LOAD: EXT.

NOTE: The following controls are located on the wave generator circuit board. Refer to Figure 1 (fold-out from Page 36) for their location. Position each control at its center of rotation.

- () BIAS.
- () FEEDBACK.
- () SYMMETRY.
- () METER CAL.

- () Plug the line cord into an AC outlet.
- () Turn the POWER switch ON.
- () Adjust the FEEDBACK control until the panel meter reads between 6 and 8 on the 0-10 scale.
- () Set the external voltmeter to read 10 volts AC.
- () Connect the external voltmeter common lead to the black sine wave output binding post. Connect the other voltmeter lead to the red sine wave output binding post.
- () Adjust the METER CAL control until the panel meter reads the same, on the 0-10 scale, as the voltmeter.
- () Disconnect the external voltmeter.
- () Set the oscilloscope to display a 1000 Hz waveform at an amplitude of 10 volts.
- () Connect the oscilloscope to the sine wave output binding posts.

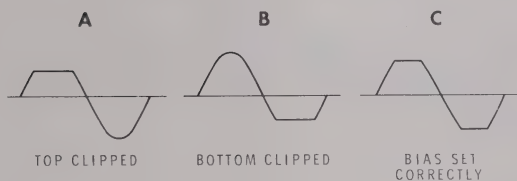


Figure 2

- () Rotate the FEEDBACK control fully clockwise. Note that the positive or negative half of the waveform is clipped as shown in part A or B of Figure 2.
- () Adjust the BIAS control so both halves of the waveform are clipped equally, as shown in Part C of Figure 2.
- () Adjust the FEEDBACK control until the panel meter indicates 10 volts.
- () Disconnect the oscilloscope.

NOTE: In the following two steps, if no change can be detected in the panel meter reading, it will not be necessary to readjust the feedback control.

- () Turn the TENS FREQUENCY switch to each position, 10 through 100. Leave the switch in the position where the panel meter indicates the lowest voltage.
- () Turn the MULTIPLIER switch to each position, X1 through X1000. Leave the switch in the position where the panel meter indicates the lowest voltage.
- () Readjust the FEEDBACK control so that the panel meter indicates 10 volts.
- () Reset the FREQUENCY and MULTIPLIER switches for a 1000 Hz output at 10 volts (MULTIPLIER at X100, TENS FREQUENCY at 10).
- () Connect the oscilloscope to the square wave output binding posts. Set the oscilloscope input switch to AC.

NOTE: The very fast rise time (leading edge) of the square wave signal is very rich in harmonics, extending into the megahertz range. Low frequency oscilloscopes may respond in various ways to this signal. The leading edge may be "rounded off" through the roll-off characteristics of the oscilloscope, or frequency compensation (with peaking coil, for instance) may lead to "ringing" or "overshoot". Even the leads between the generator and oscilloscope may affect the pattern displayed.

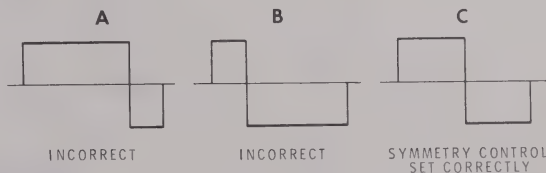
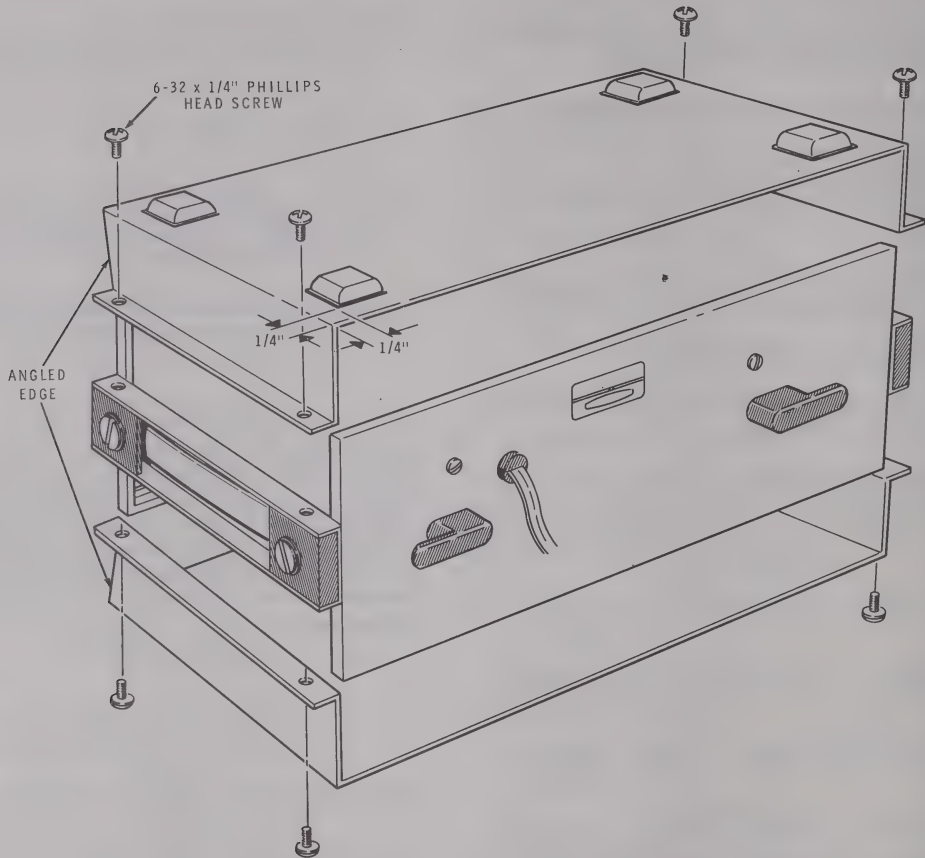


Figure 3

- () Rotate the SYMMETRY control until the positive and negative halves of the square waveform are equal, as shown in part C of Figure 3.

This completes the adjustments. Turn off the power and remove the AC plug from the socket. Proceed to Final Assembly.



PICTORIAL 21

FINAL ASSEMBLY

Refer to Pictorial 21 for the following steps.

Locate eight 6-32 x 1/4" phillips head screws, two cabinet half shells, and four plastic feet.

- () Turn the instrument upside down and install one of the cabinet half shells with four 6-32 x 1/4" phillips head screws. The angled edge of the cabinet is the front; this edge should protrude over the bezel.
- () Remove the backing paper from a plastic foot. Affix the foot about 1/4" from both edges at one corner of the cabinet bottom.

- () Likewise, affix the remaining three feet on the other three corners of the cabinet bottom.
- () Turn the instrument over and install the other cabinet half shell with four 6-32 x 1/4" phillips head screws.
- () Remove the protective paper from the blue and white label and affix it to the rear panel as shown.

This completes the assembly of the Sine-Square Audio Generator.

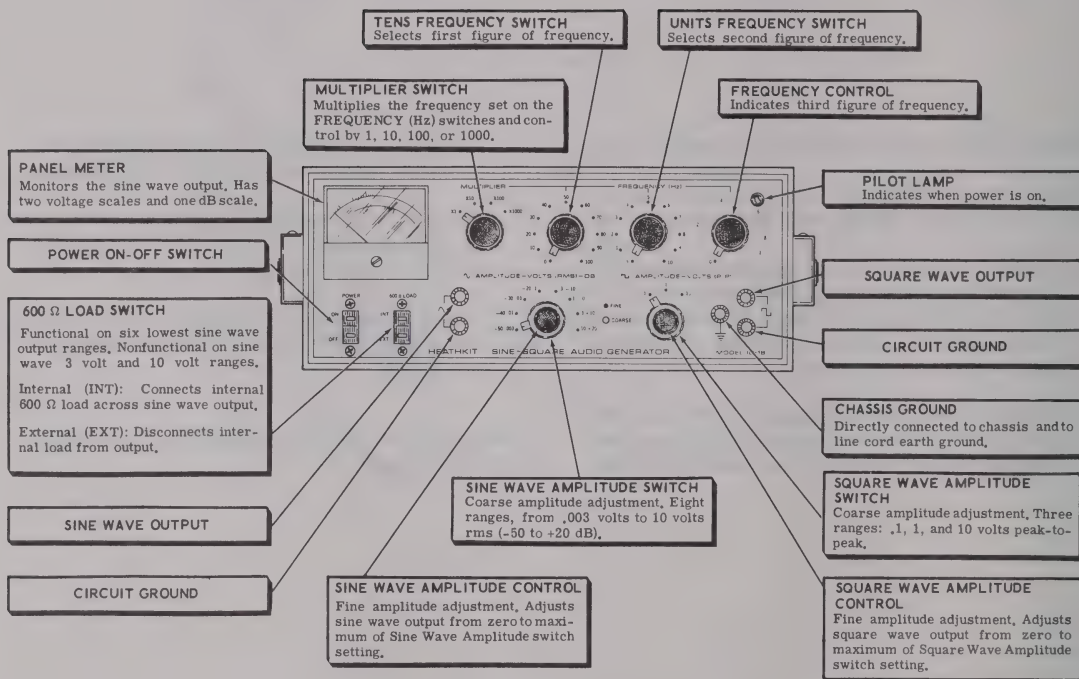


Figure 4

OPERATION

Refer to Figure 4, which describes each of the front panel controls and terminals, before you read the remaining material in this section.

FREQUENCY SELECTION

To select a given frequency, set the TENS and UNITS FREQUENCY switches to correspond with

the first two figures of the frequency. If a third figure is required, set the FREQUENCY control to the correct number. Then set the MULTIPLIER switch to the appropriate position to multiply the switch and control settings by the required multiplying factor.

EXAMPLES:

SWITCH AND CONTROL SETTINGS

SELECTED FREQUENCY	MULTIPLIER	TENS FREQUENCY	UNITS FREQUENCY	FREQUENCY CONTROL
60 Hz	X1	60	0	0
60 Hz	X10	0	6	0
400 Hz	X10	40	0	0
1520 Hz	X100	10	5	.2
15.2 kHz	X1000	10	5	.2

SINE WAVE AMPLITUDE

The output of the Audio Generator must be properly terminated to obtain accurate meter indications.

To obtain correct meter readings with a high impedance load (10 k Ω or more); set the 600 Ω LOAD switch to INT, and set the SINE WAVE AMPLITUDE switch to the nearest full scale value above the desired output level. Then adjust the SINE WAVE AMPLITUDE control to give the desired output on the proper meter scale. **EXAMPLE:** For an output voltage of 7.3 volts, set the SINE WAVE AMPLITUDE switch to 10 volts. Then turn the SINE WAVE AMPLITUDE control to give a 7.3 reading on the 0-10 scale of the meter. **EXAMPLE:** For an output of .025 volt, set the SINE WAVE AMPLITUDE switch to .03 volt. Then turn the SINE WAVE AMPLITUDE control to give a 2.5 reading on the 0-3 meter scale.

To obtain correct meter readings with an external 600 Ω load (1 volt maximum output signal level): set the LOAD switch to EXT and proceed as before.

SQUARE WAVE AMPLITUDE

To select a square wave output level, set the COARSE SQUARE WAVE AMPLITUDE switch to the lowest range that includes the desired voltage. Then adjust the FINE SQUARE WAVE AMPLITUDE control until the required voltage is produced. The front panel voltage ranges (.1v, 1v, and 10v) are for loads of 2000 Ω impedance or more. Output level may be measured with a high impedance AC voltmeter or with an oscilloscope. Remember that a square wave is measured in peak-to-peak volts and that most AC voltmeters indicate rms volts.

CAUTION: The square wave generator output is DC-coupled to avoid poor low frequency response (see "Square Wave Testing" on Page 52). The output is a DC signal that varies from zero to some positive value when measured at the

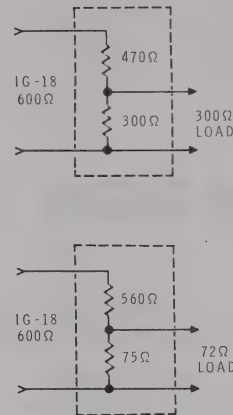


Figure 5

output terminals. Do not connect this generator output into DC circuitry without using capacitive coupling. (Observe proper capacitor polarity.) Do not short the output terminals at maximum (10.0v) output.

IMPEDANCE MATCHING

In general, impedance matching is not critical in test work. However, if close matching is required, matching pads may be constructed using composition resistors as shown in Figure 5. This Figure shows two examples for matching the 600 Ω output to different input leads. Since these pads also act as voltage divider networks, the input voltage will be less than the voltage indicated by the panel meter.

dB MEASUREMENT

The red scale on the panel meter is used for decibel (dB) comparisons. The decibel is a ratio, or comparison, of power levels. It is defined by the equation:

$$dB = 10 \log \frac{P_1}{P_2}$$

Since $P = EI$ and $I = \frac{E}{R}$, the above

equation may be restated as:

$$dB = 10 \log \frac{\frac{E_1^2}{R_1}}{\frac{E_2^2}{R_2}}$$

While the decibel is basically a relative expression between two power levels, it can be used as a quantitative expression if one of the levels is defined as a standard level.

After various levels in several industries were partly accepted as "standard levels", the audio industry settled on a standard level of 1 milliwatt

of power into a 600 ohm load. This standard level may be used in 600 ohm circuits only. In these circuits R^1 and R^2 in the above equation are equal and cancel out, simplifying the expression to:

$$dB = 10 \log \frac{E_1^2}{E_2^2}, \text{ or}$$

$$dB = 10 \log \left(\frac{E_1}{E_2} \right)^2, \text{ or}$$

$$dB = 20 \log \frac{E_1}{E_2}.$$

Accordingly, with the standard 600 Ω load across the signal output, you can read relative power on a voltmeter, such as the front panel meter on the Generator or any other voltmeter with the appropriate calibration (dB scale).

As zero dB is defined as 1 milliwatt in a 600 Ω load, and $P = \frac{E^2}{R}$, then $.001 = \frac{E^2}{600}$, or $E = \sqrt{.6}$, or $E = .775$ V. It is for this reason that the zero dB mark is in line with the 7.75 mark on the 0-10 meter scale.

APPLICATIONS

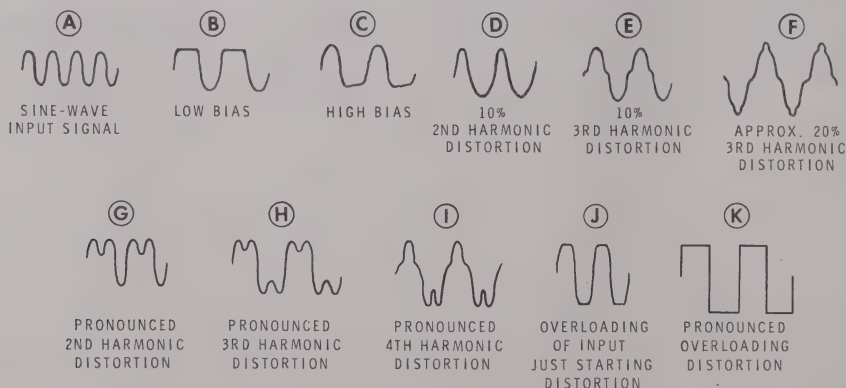
SINE WAVE TESTING

Gain and distortion checks are probably the most common types of sine wave tests that you will make with this Generator. Usually these tests are performed on an amplifier. In either of these tests, a single amplifier stage may be tested separately, or the entire amplifier may be tested.

Figure 7 shows typical connections for testing a single stage or a complete amplifier. The output from the Generator may be connected directly to the input of the amplifier being tested. If impedance matching is desirable, you can construct the matching pads described on Page 48. When connecting the signal directly to the input circuit of a transistor or a tube, use a coupling capacitor in series with the signal lead to block any DC voltage that may be present in the circuit.

To test the voltage gain, feed a signal of known amplitude (voltage) into the amplifier input and measure the resulting output. The gain is equal to the ratio of the output voltage divided by the input voltage. This measurement may be made with a voltmeter or an oscilloscope. Frequency response tests may be made by determining the gain at various frequencies.

To test for distortion, the output signal from an amplifier can be displayed on an oscilloscope and compared with the input sine wave from the Sine-Square Generator. This test will indicate if distortion is present and, if so, what kind. Figure 6 shows waveforms of several kinds of distortion.



TYPICAL DISTORTION PATTERNS OBTAINED IN AUDIO AMPLIFIER TESTING

Figure 6

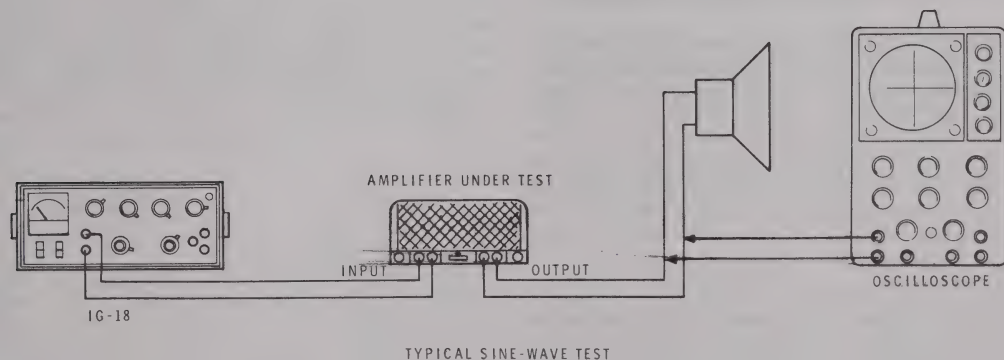
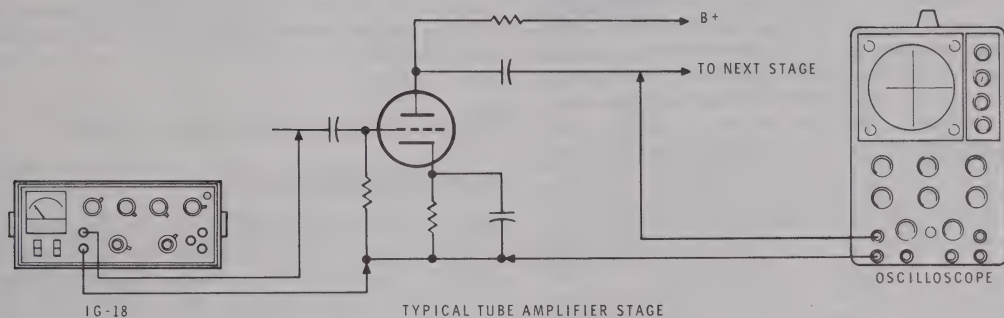
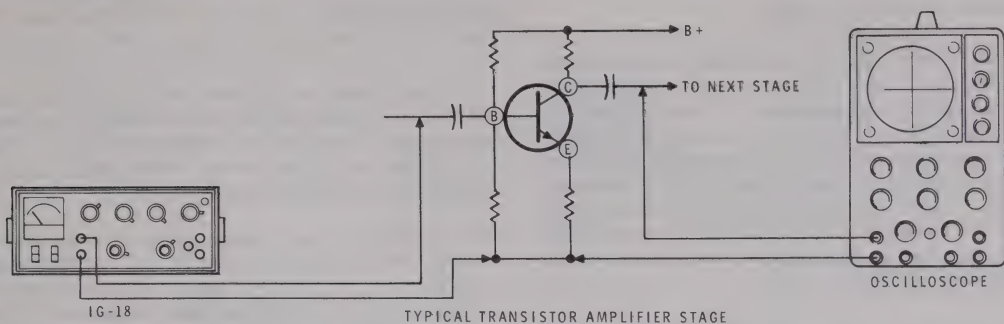


Figure 7

SQUARE WAVE TESTING

Square waves are very useful for testing amplifiers, since one square wave will perform several tests simultaneously. This occurs because the square wave is actually a complex waveform made up of many sine waves, which are the fundamental frequency and all of the odd harmonics of that frequency. Therefore, in one operation, the square wave tests a circuit at many different frequencies, from one tenth to ten times the fundamental frequency.

The flat top of the square wave tests the low frequency response of a circuit. This happens because the flat top more closely resembles low frequencies, or short burst of DC voltage. The vertical portion of the square wave contains high harmonic frequencies that test the response of the amplifier to about ten times the fundamental frequency. Thus, two settings, 100 Hz and 10 kHz would check the frequency response of an amplifier from 10 Hz to 100,000 Hz.

Figure 8 shows the types of square wave response patterns that might be seen on an oscilloscope. If the corners of the square wave are rounded off, it means that some of the higher harmonics are missing. If the flat top portion of the square wave is tilted, it means that the low frequency response of the amplifier is faulty.

Square wave tests are also an excellent way to test the response of the vertical amplifiers of an oscilloscope. Connect the square wave to the os-

cilloscope vertical input and check the shape of the square wave on the oscilloscope screen.

The sine wave and square wave outputs of your Generator can be used at the same time without detrimental effects to either waveform. This makes the use of recurrent sweep oscilloscopes especially easy with this instrument.

For example, when making stage gain measurements on an amplifier with an oscilloscope, connect the sine wave output of the Generator to the input of the stage being measured. Connect the square wave output to the external sync connector of the oscilloscope. Measurements can now be made through a number of amplifier stages without readjusting the oscilloscope sync controls, regardless of how small or how large the signal is.

SPECIAL GENERATOR APPLICATIONS

Impedance Measurements

Figures 9A and 9B show how to measure the input impedance of an amplifier or of a similar circuit. The method is exact if the impedance is resistive, approximate if it is reactive. For measuring input impedances that are high compared to the Generator output impedance, use the arrangement shown in Figure 9A. It may be necessary to use variable resistors of several different values, such as 10 k Ω , 100 k Ω , 1 M Ω , and 5 M Ω , to obtain the correct indication on the external AC meter.

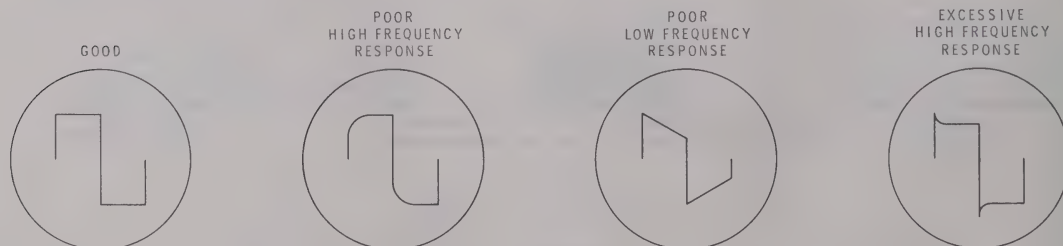


Figure 8

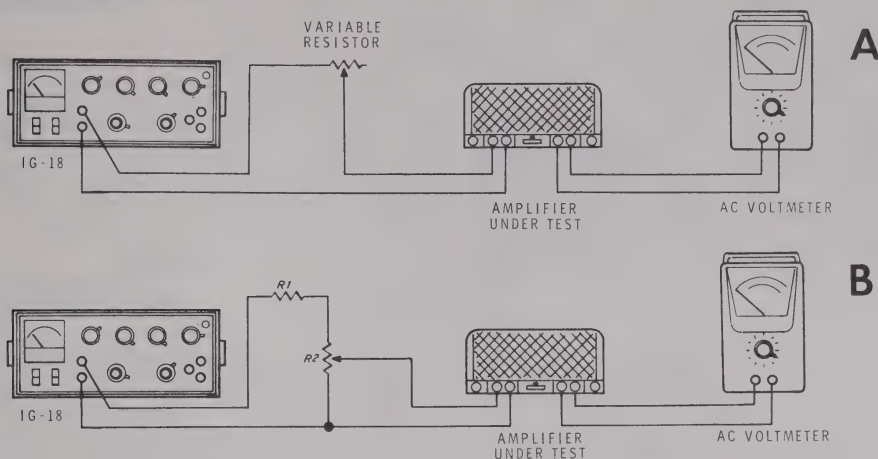


Figure 9

Set the Generator to a low frequency, such as 20 Hz, short out the variable resistor, and set the signal level of the Generator to give a convenient reading on the AC voltmeter. Remove the short from the variable resistor. The value of the variable resistor is then adjusted until the reading on the meter drops to $1/2$ of the former value. The resistance of the variable resistor is then equal to the unknown input impedance of the amplifier. The resistance of the variable resistor can be measured with an ohmmeter. If this same check were made at higher frequencies, the input impedance would appear to be smaller because some of the signal would be shorted out by the input capacitance of the amplifier.

For low input impedances, of a few hundred ohms or less, connect the circuit as shown in Figure 9B. Fixed series resistor R_1 should be at least ten times the input resistance to be measured. The value of this resistor is not important if it is made large enough. The output voltage is set to some convenient value, as before, with variable resistor R_2 disconnected.

When R_2 is connected again, it is adjusted until the meter reading drops to half of the former value. The resistance of variable resistor R_2 is then equal to the input resistance of the amplifier.

FREQUENCY MEASUREMENTS

An oscilloscope and the Generator can be used to measure the frequency of an unknown signal. Place the oscilloscope horizontal frequency selector in the horizontal input position. Connect a sine wave from the Generator to the horizontal input of the oscilloscope. Connect the unknown frequency to the vertical input of the oscilloscope. Do not use square waves to make these tests.

When the size of the generator signal is adjusted to approximately the same size as that of the unknown signal, and the oscilloscope is properly adjusted, waveforms called Lissajous figures will be seen on the oscilloscope. Interpreting these waveforms correctly will show the frequency of the unknown signal.

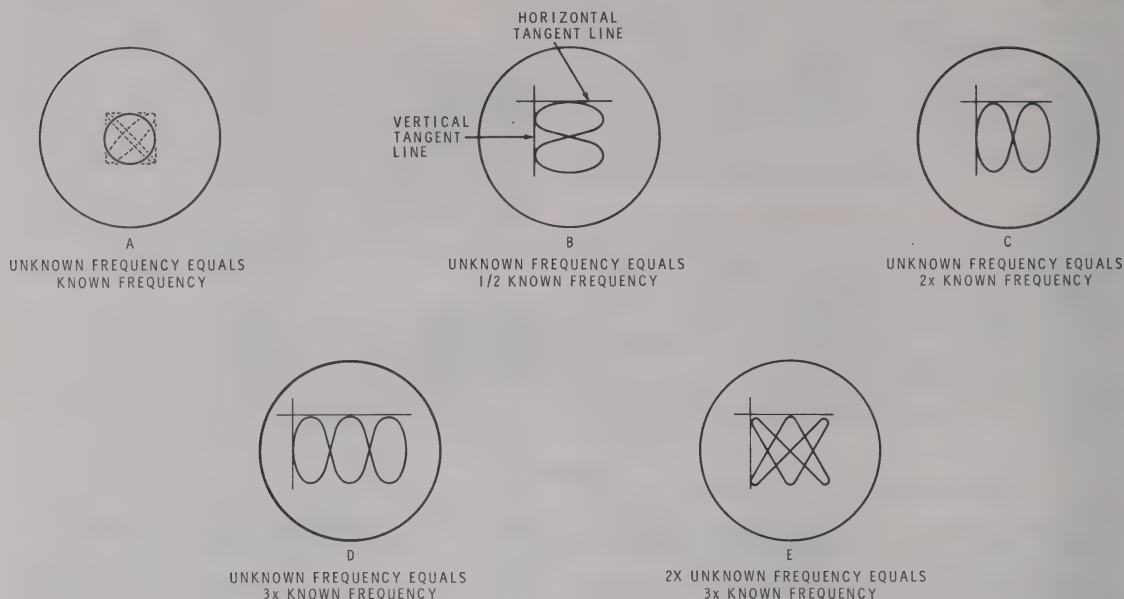


Figure 10

To measure an unknown frequency, adjust the Generator frequency until the pattern comes as close as you can adjust it to the circle shown in Part A of Figure 10. This circle may appear to revolve in such a way that it alternately assumes each of the following forms: a slanting line to the left, an ellipse, a circle, an ellipse, again, a slanting line to the right, an ellipse, etc. Often, it will be almost impossible to keep the circle from revolving.

When the circle is displayed on the oscilloscope screen, the frequency of the unknown signal is then exactly equal to the frequency of the Generator, as shown on the Generator dial. The accuracy of the measurement is the same as the accuracy of the Generator frequency.

Unknown frequencies that are beyond the frequency limits of the Generator can be measured by using more complex Lissajous patterns, such as the ones shown in Parts B, C, D, and E of Figure 10. In these cases, the pattern shown on the oscilloscope gives the ratio between the frequency of the Generator signal and the frequency of the unknown signal. Determining the frequency of the unknown signal then becomes a matter of simple arithmetic. The frequency of the unknown signal can be calculated using the following formula:

$$\text{Unknown Frequency} = \frac{T_h \times F}{T_v}$$

In the above formula, T_h is the number of loops that touch the horizontal tangent line; F is the Generator frequency; and T_v is the number of loops which touch the vertical tangent line.

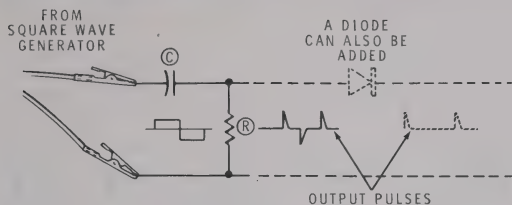


Figure 11

PULSE MEASUREMENTS

Fast rise time trigger pulses can easily be formed at the square wave output of the Generator by the addition of a single resistor and capacitor. See Figure 11. The addition of a diode will eliminate the positive or negative pulses that are not wanted.

The size of the resistor and capacitor depends on the desired frequency and how wide a pulse you wish to have. A rule of thumb for pulse width is that it should be about 1/10 as wide as the positive one-half of the square wave, at the frequency desired. The sizes of the resistor and capacitor are generally found by experimenting, but a close approximation can be found in the following manner:

$$\frac{1}{\text{freq. of square wave}} \times 1/2 = \text{time of 1/2 cycle of square wave}$$

The above $\times 1/10$ = width of average pulse quantity in fractions of a second

Collecting the above together we get:

$$\frac{1}{\text{freq. of square wave}} \times 1/20 = \text{time of pulse width for average pulse.}$$

To find the size of the pulse that a resistor and capacitor will give, multiply the resistance in ohms by the capacitance in "farads" ($1 \mu\text{F} = .000001$ farads). The answer will be the time constant of the two parts and a portion of time usually expressed in "microseconds" (one-millionths of a second). If the "time constant" of the resistor and capacitor you choose does not produce the pulse width you want, change the value of either or both parts.

For example, if you want positive pulses at a frequency of 10 kHz:

$$\frac{1}{10,000} \times 1/20 = 5 \text{ microseconds}$$

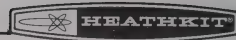
The following calculations show that the time constant of a 10 k Ω resistor and .0005 μF capacitor will give the desired 5 microsecond pulse.

$$500 \times 10^{-12} \text{ (capacitance, .0005 } \mu\text{F)} \times 1 \times 10^4 \text{ (resistance, 10 k}\Omega\text{)} =$$

$$500 \times 10^{-8} = 5 \times 10^{-6} = .000005 = 5 \text{ microseconds}$$

Another way this time constant can be calculated is as follows:

$$.0000000005 \text{ (capacitance, .0005 } \mu\text{F)} \times 10,000 \text{ (resistance, 10 k}\Omega\text{)} = .000005 = 5 \text{ microseconds}$$



IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the builder.
2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the Soldering section of the Kit Builders Guide.
3. Check to be sure that all transistors are in their proper locations. Make sure each transistor lead is connected to the proper point.
4. Check the values of the parts. Be sure the proper parts have been wired into each circuit as shown in the Pictorial Diagrams. It would be easy, for example, to install a 62 k Ω (blue-red-orange) resistor where a 620 k Ω (blue-red-yellow) resistor should have been installed.
5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring, or on the circuit board foil.
6. If the trouble still is not located and a voltmeter is available, check the voltage readings against those shown on the Schematic Diagram. A review of the Circuit Description may help you locate the trouble.

NOTE: Refer to the Circuit Board X-Ray Views on Page 67 and Photographs on Page 69 for the physical location of parts.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the Service and Warranty sections of the "Kit Builders Guide", and to the "Factory Repair Service" information on Page 59 of this Manual.

TROUBLESHOOTING CHART

DIFFICULTY	POSSIBLE CAUSE AND SUGGESTED CURE
Pilot lamp lights. No sine or square wave output.	1. All controls set at zero. 2. Measure the B+ voltage at point A on the generator circuit board. If the voltage is low or there is no voltage, refer to the next Difficulty on this Chart. 3. Feedback control not set properly. (Refer to Adjustments section on Page 41.) 4. Check transistors Q1, Q2, Q5, Q4, and Q3 in that order. 5. Open filament in lamp L1. 6. Wrong part value, improper connection, or faulty part in notch filter circuits (units and tens switches). (Make checks at other frequency settings to test this possibility.)
B+ voltage low or no B+ voltage.	Measure the resistance of the generator circuit board at TP1 as described in the step under "Tests" on Page 39. If this resistance is less than 1500 Ω , apply the checks on the previous page to the generator circuit board. If the resistance is 1500 Ω or greater, check the following: 1. Transistor Q10. 2. Diodes D5 and D6. 3. Zener diode D7. 4. Capacitors C1, C2, C3, and C4. 5. Transformer primary windings.
No sine wave output. Square wave output ok.	1. Short circuit or excessive load at sine wave output terminals. 2. Check control R106. 3. Check capacitor C6.
No square wave output. Sine wave output ok.	1. Short circuit or excessive load at square wave output terminals. 2. Symmetry trimmer not adjusted properly. 3. Check transistors Q6, Q7, and Q8. 4. Check control R101. 5. Check capacitor C8. 6. Frequency set too low.
Bottom of square wave goes below zero.	1. D8 open.

DIFFICULTY	POSSIBLE CAUSE AND SUGGESTED CURE
Meter inoperative. Sine wave output ok,	1. Check diodes D3 and D4. 2. Check control R21. 3. Meter pointer stuck. 4. Meter coil open. WARNING: When testing the meter for continuity, use <u>only</u> the highest resistance range of the ohmmeter.
Sine wave distorted,	1. Feedback control set too high. 2. Bias control not set correctly. 3. Check Q10. 4. Check Q5, Q4, Q1, Q2, and Q3. 5. Improper ground connections between Generator and associated equipment. 6. Low line voltage.

FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) If you wish, you can deliver your kit to a nearby Heath Authorized Service Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heath Authorized Service Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heath Authorized Service Center, please ship it to the factory at Benton Harbor, Michigan and follow the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.

- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan.

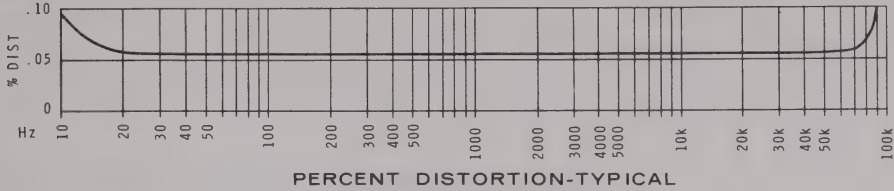
Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least **THREE INCHES** of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

SPECIFICATIONS

SINE WAVE OUTPUT

Frequency Range.	1 Hz to 100 kHz.
Output Voltage Ranges.	0 - .003 0 - .01 0 - .03 0 - .1 0 - .3 0 - 1 0 - 3 0 - 10
Internal Load.	Internal 600 Ω load available on .003, .01, .03, .1, .3, and 1 volt ranges.
dB Ranges.	-62 to +22 dB. -12 to +2 dB on meter; -50 to +20 dB in eight 10 dB switch positions. +2 dB maximum into 600 Ω load.
Output Variation.	± 1 dB from 10 Hz to 100 kHz.
Output Indication.	Two voltage scales and one dB scale on front panel meter.
Output Impedance.	10 volt range: 0-1000 Ω . 3 volt range: 800-1000 Ω . 1 volt range and lower: 600 Ω .
Meter Accuracy.	$\pm 10\%$ of full scale with proper load termination.



Distortion.	Less than .1% from 10 Hz to 20 kHz.
Type Of Circuit.	Differential amplifier with complementary pair output, Notch filter frequency determination.

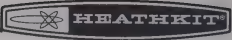
SQUARE WAVE OUTPUT

Frequency Ranges.	5 Hz to 100 kHz.
Output Voltage Ranges.	0-.1 V, 0-1 V, and 0-10 V zero-to-peak into 2000 Ω or higher load.
Output Impedance.	52 Ω on .1 V and 1 V ranges; Up to 220 Ω on 10 V range.
Rise Time.	Less than 50 nanoseconds.

GENERAL

Frequency Selection.	First two significant figures on 0-100 and 0-10 switches each in ten steps. Third figure on 0-1 control. Multiplier switch: X1, X10, X100, X1000.
Frequency Error	Within $\pm 5\%$ of first and second digit.
Power Requirements.	105-125 VAC or 210-250 VAC, 50/60 Hz, 6 Watts.
Dimensions.	5-1/8" high x 13-1/4" wide x 7" deep.
Net Weight.	7 lbs.

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.



CIRCUIT DESCRIPTION

Refer to the Block Diagram on Page 65 and to the Schematic Diagram (fold-out from Page 75) while reading this Circuit Description.

The circuit of the Sine-Square Audio Generator

includes three principal sections: The Sine Wave Generator (including the meter and output attenuator circuits), the Square Wave Generator and the Power Supply. Each of these Sections will be described separately.

SINE WAVE GENERATOR

The sine wave oscillator circuits consists of differential amplifier transistors Q1 and Q2; voltage amplifier transistor Q3; power amplifier transistors Q4 and Q5; and the positive and negative feedback loops. Positive (regenerative) feedback comes from the common emitter output of transistors Q4 and Q5, and is coupled to the base of transistor Q2 through the lamp L1, the arm of feedback control R7, and resistor R6. Negative (degenerative) feedback comes through the notch filter and is directly coupled to the base of transistor Q1.

Oscillation occurs due to the positive feedback. Without negative feedback, the circuit would oscillate at some indeterminate frequency; however, the notch filter, which passes all frequencies except the one to which it is tuned, provides the negative feedback to the base of transistor Q1. This negative feedback prevents oscillation at all frequencies except the one that is not passed, permitting the system to oscillate at only the selected frequency.

The tuned frequency of the RC notch filter circuit may be calculated by the general formula:

$$F = \frac{1}{2 \pi RC}$$

where F is frequency in hertz, R is resistance in ohms, and C is capacitance in farads. However, since this notch filter is a specialized RC network in which there are two resistances and two capacitances, the formula for this network then becomes:

$$F = \frac{1}{2 \pi \sqrt{R_1 R_2} \sqrt{C_1 C_2}}$$

Since R_1 and R_2 will always be equal, the formula simplifies to:

$$F = \frac{1}{2 \pi R \sqrt{C_1 C_2}}$$

In the notch filter in the Sine-Square Audio Generator R may consist of one or several resistors in parallel; or

$$R = \frac{1}{\frac{1}{R_x} + \frac{1}{R_y} + \frac{1}{R_z}}; \quad C_1 = C_x; \quad \text{and } C_2 = C_y.$$

R_x represents the resistance value selected by the Tens Frequency switch for a particular frequency. This resistance may consist of one resistor, or a parallel combination of several resistors. For example; for 20 Hz the two 5000 Ω resistors are selected and $R_x = 5000 \Omega$, for 40 Hz the two 2500 Ω resistors are selected and $R_x = 2500 \Omega$, for 60 Hz both the 5000 Ω and the 2500 Ω resistors are selected in parallel and $R_x = 1670 \Omega$.

R_y represents the resistance value selected by the Units Frequency switch for a particular frequency. The operation of this switch is identical to that of the Tens Frequency switch, except that the resistance values are ten times those of the Tens Frequency switch.

R_z represents the resistance value of the Frequency Control when adjusted for a particular frequency.

C_x and C_y represent the capacitors on the Multiplier switch. The value of C_y will always be 10 times larger than the value of C_x for all positions of the Multiplier switch.

As shown in the general formula $F = \frac{1}{2 \pi RC}$, the

tuned frequency of a notch filter is inversely proportional to the value of its resistances and capacitances. Therefore, to achieve an increase in frequency the resistance must decrease. Likewise, for a tenfold increase in frequency, by using the Multiplier switch, the capacitance must decrease tenfold.

Any tendency of the oscillator to produce signals of increasing amplitude is controlled by lamp L1. If the oscillator output increases, more current is fed through the feedback circuit and through lamp L1. This increased current causes the filament of the lamp to heat slightly, which causes its resistance to increase. This increase in resistance attenuates the feedback signal to the base of transistor Q2. The result is a regulated output from transistor Q2.

DC base bias is provided to Q1 and Q2 through a voltage divider that consists of resistors R5 and R6, and control R7. (Resistor R3 decreases the gain of the differential amplifier to make it more stable.) The voltage at the lower end of this divider, and therefore at the bases of Q1 and Q2, is made adjustable by being connected to the arm of Bias control R9, which is connected in a DC voltage divider with R8 and R10.

The signal from the differential amplifier is direct coupled from the collector of Q2 to the base of voltage amplifier transistor Q3. From the collector of Q3, the signal is direct coupled to the base of Q4, and through diodes D1 and D2 to the base of Q5. These diodes maintain a 1.2 volt difference between the bases of transistors Q4 and Q5.

Q4 and Q5 form an emitter follower complementary-pair amplifier with no voltage gain and a low impedance output. The output signal from this stage is coupled to the square wave circuits as a trigger signal and to the sine wave output attenuator.

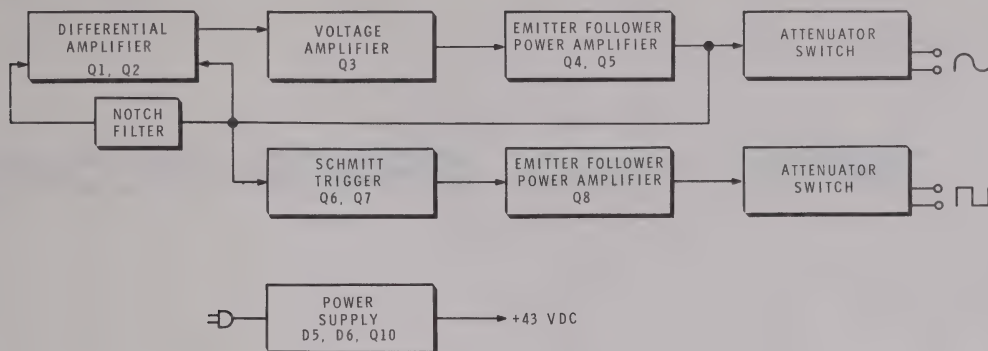
SINE WAVE OUTPUT ATTENUATOR

The sine wave signal from Q4 and Q5 is coupled through capacitor C6 to Sine Wave Amplitude control R106. From R106, the signal is coupled through isolating resistor R107 to the meter circuit and to the Sine Wave Amplitude switch.

The resistor network on two sections of this switch comprise an eight-step voltage divider (R109 to R121) which proportionately divides the signal into steps of 10 dB each. The selected voltage level is applied to the sine wave output terminals. The remaining section of the switch permits internal load resistor R122 to be connected across the output terminals in the six lowest output ranges.

METER CIRCUIT

Resistor R108 and meter calibration control R21 comprise a voltage divider through which some of the signal from resistor R107 is bypassed for monitoring by the panel meter. Diodes D3 and D4, and load resistors R24 and R25 form a half-wave bridge rectifier circuit for the output meter.



BLOCK DIAGRAM

SQUARE WAVE GENERATOR

The square wave section consists of a Schmitt trigger circuit Q6 and Q7, a power amplifier Q8, and the square wave attenuator. The square wave is produced by the Schmitt trigger circuit, which is triggered by a sine wave signal that is coupled through resistor R15 and Symmetry control R16 to the base of Q6.

The Schmitt trigger circuit has two stable states: one in which Q7 is conducting and Q6 is cut off, and the other in which Q6 is conducting and Q7 is cut off. The switching time between these two states is extremely short, which permits the circuit to produce a square wave with a very fast rise time.

The switching is controlled by the voltage on the base of Q6. This voltage varies with the rising and falling voltage of the sine wave input. Symmetry control R16 is adjusted to produce time intervals between switching on and switching off that are of equal length; therefore, producing a symmetrical square wave.

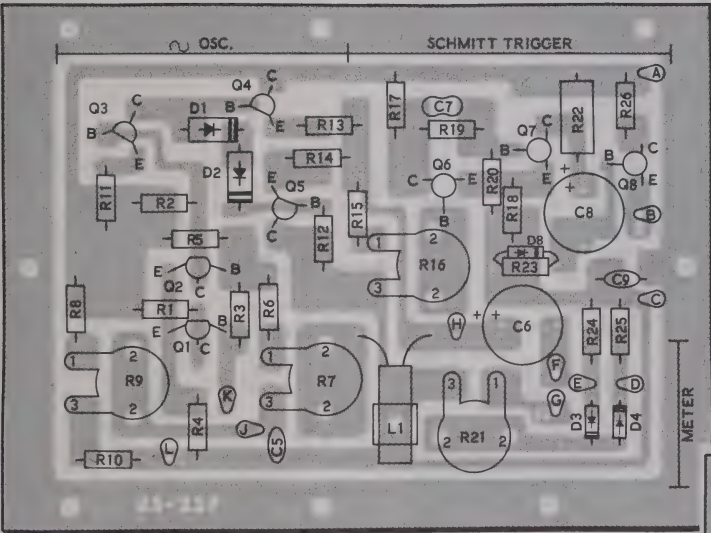
The Schmitt trigger output from the collector of transistor Q7 is coupled through capacitor C8 to the base of emitter follower transistor Q8, which provides a low impedance output with no voltage gain. D8 protects the base of Q8 from excessive negative voltage. The output from Q8 passes directly to Square Wave Amplitude control R101. From R101, the square wave is applied through the attenuator network on the Square Wave Amplitude switch to the square wave output terminals.

POWER SUPPLY

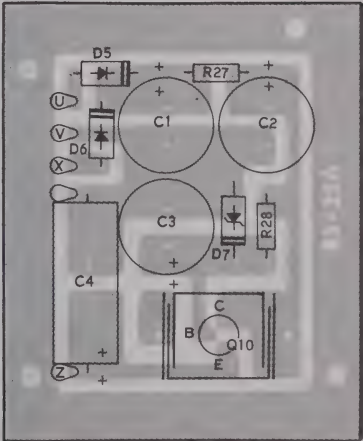
Dual-primary power transformer T1 can be wired to operate from either 120 VAC or 240 VAC. The output from the secondary of T1 is rectified by diodes D5 and D6 in a full wave rectifier circuit, and filtered by the pi filter consisting of capacitors C1 and C2 and resistor R27.

Zener diode D7 provides a regulated reference voltage for the base of voltage regulator transistor Q10, which regulates the DC output at 43 volts. Capacitor C4 grounds AC feedback from the sine wave generator at high frequencies.

CIRCUIT BOARD X-RAY VIEWS

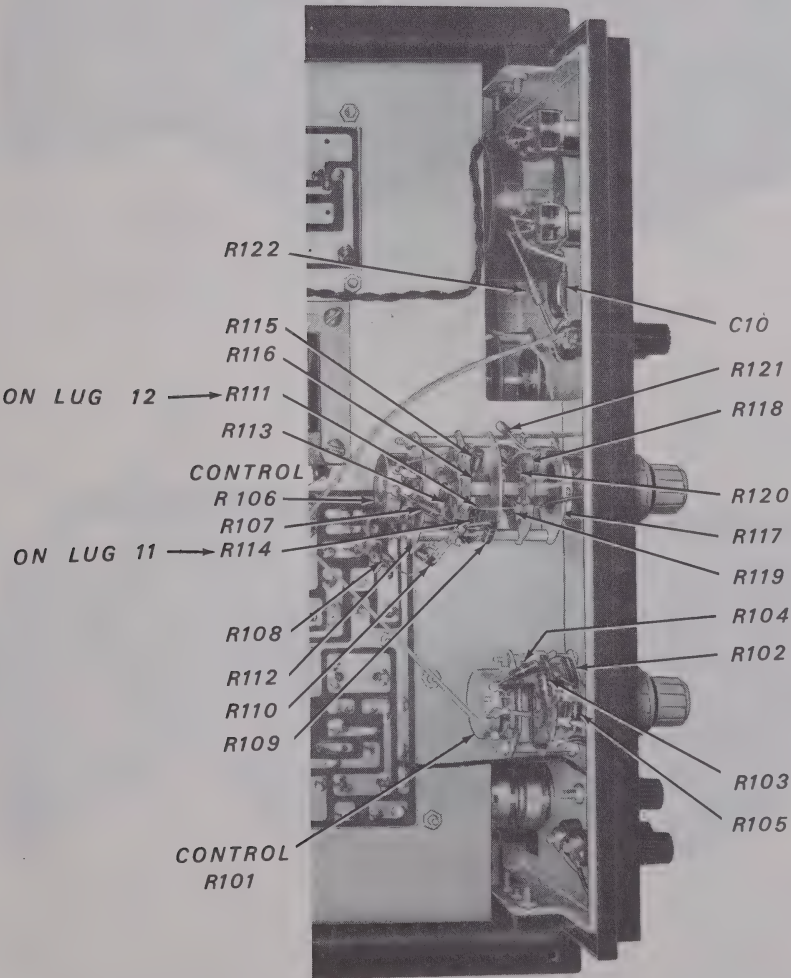


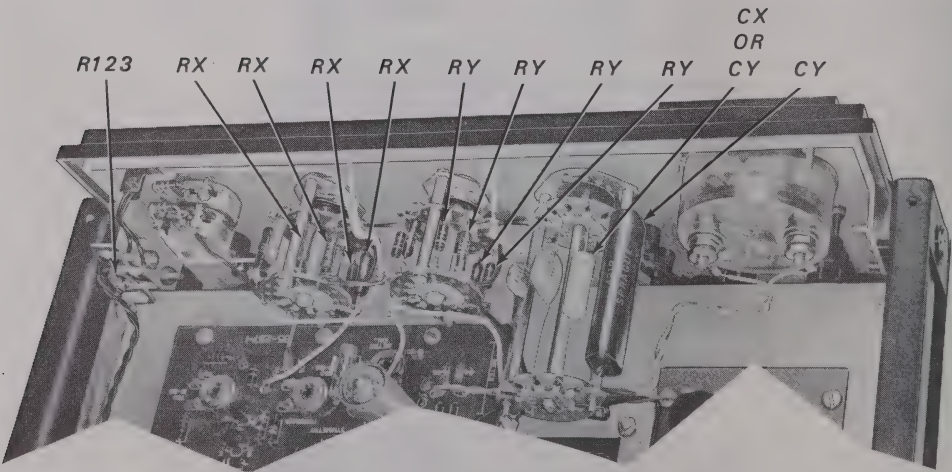
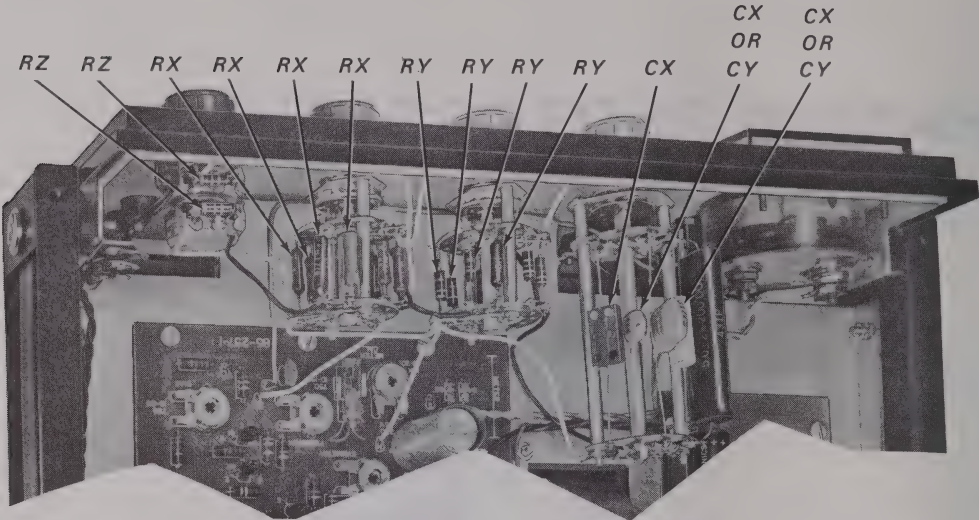
WAVE GENERATOR CIRCUIT BOARD
(VIEWED FROM FOIL SIDE)



POWER SUPPLY
CIRCUIT BOARD
(VIEWED FROM FOIL SIDE)

CHASSIS PHOTOGRAPHS





REPLACEMENT PARTS PRICE LIST

WAVE GENERATOR

The following prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from an authorized Service Center or Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

To order parts, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to Replacement Parts in the "Kit Builders Guide".

PART No.	PRICE Each	DESCRIPTION
-------------	---------------	-------------

RESISTORS

1/2 Watt

1-54	.10	15 Ω
1-66	.10	150 Ω
1-97	.10	1100 Ω
1-98	.10	1600 Ω
1-89	.10	2400 Ω
1-16	.10	4700 Ω
1-20	.10	10 k Ω
1-47	.10	56 k Ω
1-29	.10	220 k Ω

1 Watt

1-56-1	.10	1200 Ω
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CAPACITORS

20-128	.35	470 pF resin
21-16	.10	.01 μ F disc
25-200	.50	.68 μ F electrolytic

PART No.	PRICE Each	DESCRIPTION
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CONTROLS

10-155	.35	750 Ω
10-201	.40	10 k Ω

DIODES-TRANSISTORS

56-26	.25	Crystal diode
56-56	.20	Silicon diode
57-65	1.35	Silicon diode
417-94	1.00	2N3416 transistor
417-154	1.65	2N2369 transistor
417-201	.50	X29A829 transistor

HARDWARE

250-89	.05	6-32 x 3/8" screw
254-1	.05	#6 lockwasher
259-1	.05	#6 solder lug
252-3	.05	6-32 nut
250-175	.05	2-56 x 3/8" screw
254-7	.05	#3 lockwasher
252-51	.05	2-56 nut

MISCELLANEOUS

206-24	.15	Lamp clip
412-66	.75	Lamp
85-257-2	1.25	Wave generator circuit board
331-6	.15	Solder
200-516	1.40	Chassis
	2.00	Manual (See front cover for part number.)
490-5	.10	Nut starter

POWER SUPPLY

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
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RESISTORS-CAPACITORS

1-1	.10	47 Ω 1/2 watt resistor
1-89	.10	2400 Ω 1/2 watt resistor
25-126	.50	50 μ F capacitor

DIODES-TRANSISTOR

56-66	.90	VR 43 zener diode
57-65	1.35	Silicon diode
417-178	1.50	40389 transistor

HARDWARE

250-89	.05	6-32 x 3/8" screw
254-1	.05	#6 lockwasher
252-3	.05	6-32 nut

MISCELLANEOUS

54-205	4.20	Power transformer
85-256-2	.75	Power supply circuit board
344-50	.05/ft	Black wire
344-52	.05/ft	Red wire

SWITCH PARTS

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
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RESISTORS

1-83	.10	56 Ω
1-84	.10	62 Ω
1-66	.10	150 Ω
1-94	.10	390 Ω
1-63	.10	510 Ω
1-131	.10	620 Ω
1-96	.10	750 Ω
1-97	.10	1100 Ω
1-98	.10	1600 Ω
1-89	.10	2400 Ω

1/2 Watt, 1%

2-249	.20	2500 Ω (2.5 k Ω)
2-248	.20	3300 Ω (3.3 k Ω)
2-247	.20	5000 Ω (5 k Ω)
2-50	.20	10 k Ω
2-97	.20	25 k Ω
2-98	.20	33.3 k Ω
2-99	.25	50 k Ω
2-11	.25	100 k Ω

CAPACITORS

20-55	.20	500 pF
27-84	.75	.005 μ F

Capacitors (cont'd.)

27-83	1.55	.05 μ F
27-82	2.30	.5 μ F
27-81	4.05	5 μ F

SWITCHES-CONTROL NUT

63-485	5.00	8-position rotary with 5000 Ω control
63-486	4.20	3-position rotary with 400 Ω control
63-487	2.35	11-position rotary
63-488	2.15	4-position rotary
252-7	.05	Control nut

WIRE

344-50	.05/ft	Black wire
344-51	.05/ft	Brown wire
344-53	.05/ft	Orange wire
344-54	.05/ft	Yellow wire
344-55	.05/ft	Green wire
344-56	.05/ft	Blue wire
344-59	.05/ft	White wire

CHASSIS PARTS

PART No.	PRICE Each	DESCRIPTION
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RESISTORS

1-95	.10	560 Ω
1-23	.10	27 k Ω
1-102	.10	82 k Ω

ELECTROLYTIC CAPACITORS

25-193	.60	250 μ F
25-205	1.30	300 μ F
27-110	.20	.047 μ F Mylar

CONTROL-SWITCHES

12-96	1.15	1 M Ω dual control
60-24	.50	Rocker switch

PLASTIC PARTS

70-5	.10	Black test lead insulator
70-6	.10	Red test lead insulator
75-17	.10	Binding post base insulator
75-30	.10	Line cord strain relief, round cord
75-71	.10	Line cord strain relief, flat cord
100-16-2	.10	Binding post cap, black
100-16-18	.10	Binding post cap, red
100-699	.15	Binding post cap, green
207-3	.10	Cable clamp
261-28	.05	Plastic foot
413-10	.10	Red pilot lamp lens
261-30	.10	Line cord retainer

HARDWARE

#6 Hardware

250-227	.05	6-32 x 7/8" phillips head screw
250-26	.05	6-32 x 5/8" screw
250-304	.15	6-32 x 7/16" spacer stud
250-89	.05	6-32 x 3/8" screw
250-229	.05	6-32 x 1/4" phillips head screw
250-303	.15	6-32 x 1/4" decorative head screw
250-365	.05	#6 x 1/4" sheet metal screw
254-1	.05	#6 lockwasher
254-27	.05	#6 external-internal lock-washer
255-15	.05	#6 x 1/2" spacer
259-1	.05	#6 solder lug
252-3	.05	6-32 nut

PART No.	PRICE Each	DESCRIPTION
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Other Hardware

252-7	.05	Control nut
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-32	.05	Speednut
427-3	.10	Binding post base

METAL PARTS

90-401-2	2.60	Cabinet half shell
100-769	1.55	Front panel
100-770	1.50	Rear panel
100-771	.85	Side rail
204-759-1	.15	End cap
210-35	2.90	Bezel
211-32	.35	Handle

WIRE

Hookup Wire

344-50	.05/ft	Black
344-51	.05/ft	Brown
344-54	.05/ft	Yellow
344-55	.05/ft	Green
344-57	.05/ft	Violet
344-58	.05/ft	Gray

Other Wire

89-23	.75	Line cord
341-1	.10/ft	Black test lead
341-2	.10/ft	Red test lead

KNOBS AND BUSHINGS

455-50	.10	Single knob bushing
455-51	.10	Inner shaft knob bushing
455-52	.10	Outer shaft knob bushing
462-245	.25	Single knob
462-247	.35	Outer shaft knob
462-276	.25	Inner shaft knob

MISCELLANEOUS

253-85	.05	Felt washer
260-16	.10	Alligator clip
407-131	10.60	Meter
412-15	.20	Neon lamp
431-41	.10	2-lug terminal strip
431-35	.10	7-lug terminal strip
432-27	.40	Line cord adapter
438-13	.15	Banana plug
259-20	.05	Solder pin
421-22	.35	3/4 ampere slow-blow fuse

NOTES:

1. RESISTORS AND CAPACITORS, EXCEPT THOSE IN THE NOTCH FILTER CIRCUIT, ARE NUMBERED IN THE FOLLOWING GROUPS:
 0-99 PARTS MOUNTED ON CIRCUIT BOARDS.
 100-199 PARTS MOUNTED ON CHASSIS.
2. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (k=1000).
3. ALL CAPACITORS ARE IN μF UNLESS MARKED OTHERWISE (pF=PICOFARAD).
4. ALL SWITCHES SHOWN IN FULL COUNTERCLOCKWISE POSITION WHEN VIEWED FROM THE KNOB END.
5.  INDICATES COMMON CIRCUIT GROUND.
6.  INDICATES CHASSIS GROUND.
7. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.
8.  +DC VOLTAGES TO EITHER COMMON OUTPUT TERMINAL. ALL CIRCUIT BOARD CONTROLS FULLY CCW, ALL FREQUENCY SWITCHES AND CONTROL CCW, ALL AMPLITUDE SWITCHES AND CONTROLS FULLY CW. VOLTAGES $\pm 10\%$.
9.  +DC VOLTAGES, THE SAME AS ABOVE, EXCEPT SYMMETRY CONTROL FULLY CW.

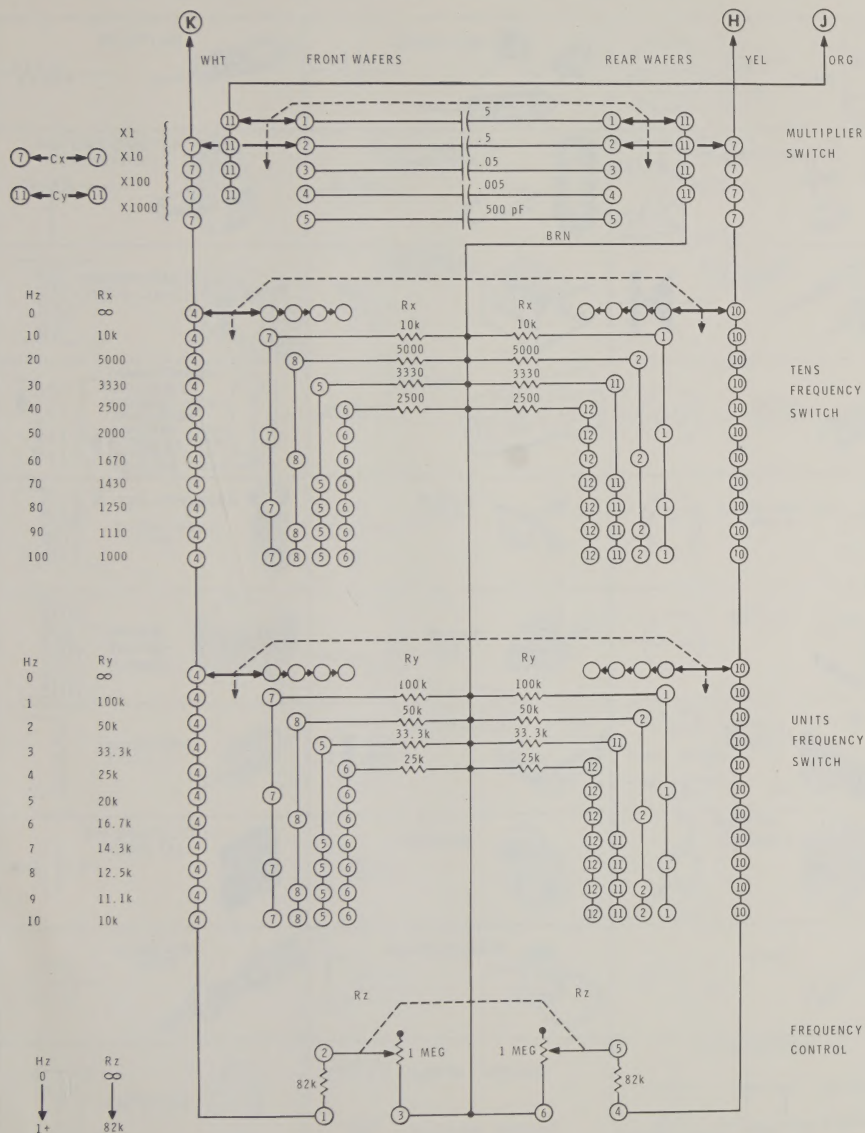
TRANSISTOR, DIODE	PART NUMBER	MAY BE REPLACED WITH	BASING DIAGRAM
Q1, Q2, Q4	417-94	2N3416	
Q3, Q5	417-201	2N2306	
Q6, Q7, Q8	417-154	2N2369	
Q10	417-178	40389	
D1, D2, D5, D6	57-65	SILICON 100 PIV, 100 mA	
D3, D4	56-26	1N191	
D7	56-66	ZENER VR43 1 WATT	
D8	56-56	1N4149	

NOTES:

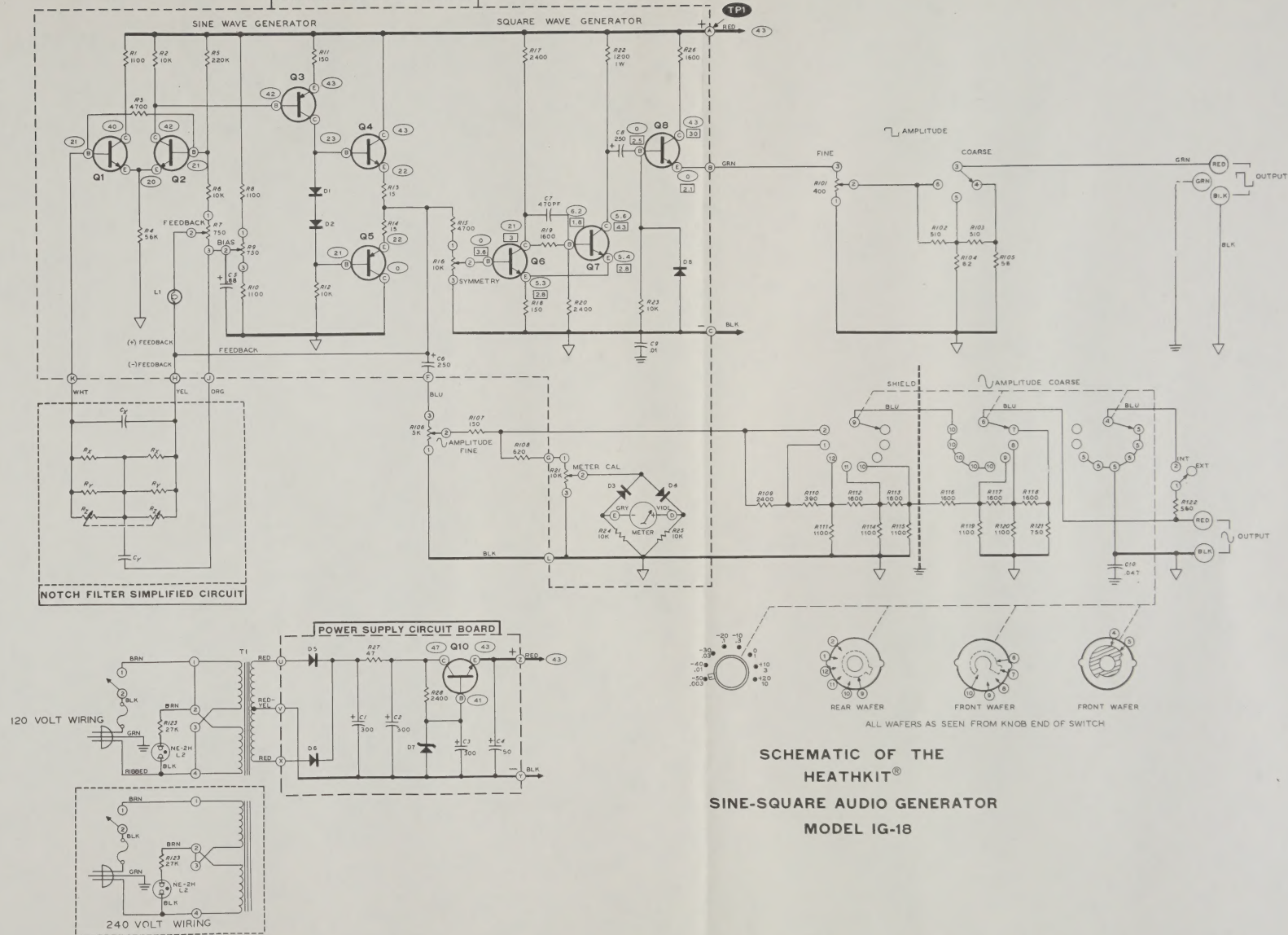
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6.  INDICATES CHASSIS GROUND.
7. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.
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9.  +DC VOLTAGES, THE SAME AS ABOVE, EXCEPT SYMMETRY CONTROL FULLY CW.

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Q6, Q7, Q8	417-154	2N2369	
Q10	417-178	40389	
D1, D2, D5, D6	57-65	SILICON 100 PIV, 100 mA	
D3, D4	56-26	1N191	
D7	56-66	ZENER VR43 1 WATT	
D8	56-56	1N4149	

NOTCH FILTER — COMPLETE CIRCUIT



WAVE GENERATOR CIRCUIT BOARD

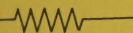
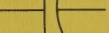
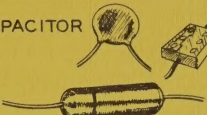
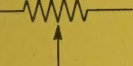
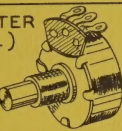
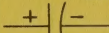
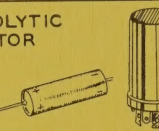
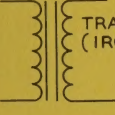
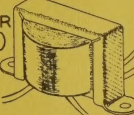
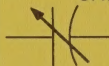
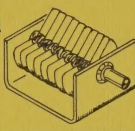
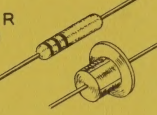
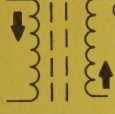
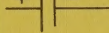
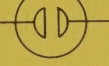
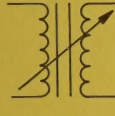
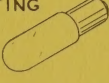
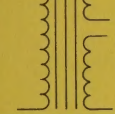
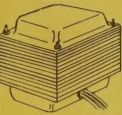
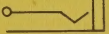
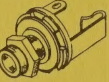
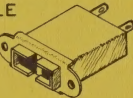
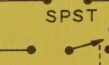
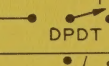
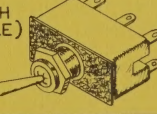
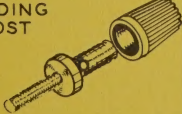
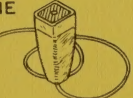


SCHEMATIC OF THE
HEATHKIT®
SINE-SQUARE AUDIO GENERATOR
MODEL IG-18

TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations

tions should prove helpful in identifying most parts and reading the schematic diagrams.

RESISTOR  	CAPACITOR  	 TUBE 
POTENTIOMETER (CONTROL)  	ELECTROLYTIC CAPACITOR  	PNP TRANSISTOR  EMITTER COLLECTOR  BASE  
TRANSFORMER (IRON CORE)  	VARIABLE CAPACITOR  	RECTIFIER (DIODE)  
TRANSFORMER (ADJUSTABLE POWDERED IRON CORE) ARROW INDICATES DIRECTION OF CORE MOVEMENT TO INCREASE INDUCTANCE  	BATTERY  	 NEON BULB 
TRANSFORMER (ADJUSTABLE CORE)  	PHONO JACK  	 ILLUMINATING BULB 
POWER TRANSFORMER  	 PHONE JACK 	 METER 
INDUCTOR (COIL)  	RECEPTACLE  	 SPST (SWITCH TOGGLE)  DPDT 
PIEZOELECTRIC CRYSTAL  	SPEAKER  	 SWITCH (ROTARY) 
 BINDING POST 	MICROPHONE  	 FUSE 
 ANTENNA GENERAL  LOOP	 EARTH GROUND  CHASSIS GROUND	CONDUCTORS  NOT CONNECTED  CONNECTED  SHIELDED

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